PA01-A Aluminum Electrolytic Capacitors 1993 N.A. Edition

PASSIVE COMPONENTS

DATA HANDBOOK

Aluminum Electrolytic Capacitors

PA01-A

1993 N.A. Edition

Philips Components

PHILIPS

SERIES 3000

QUALITY ASSURED

Our quality system focuses on the continuing high quality of our components and the best possible service for our customers. We have a three-sided quality strategy: we apply a system of total quality control and assurance; we operate customer-oriented dynamic improvement programmes; and we promote a partnering relationship with our customers and suppliers.

PERSONNEL SAFETY

Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if handled improperly. Caution is necessary if the outer case is fractured or can is punctured; vapors or dust particles should not be inhaled (proper ventilation is essential); avoid skin, eye or clothing contact. In case of liquid contact, flush thoroughly with running water promptly, then wash skin with mild soap and water. Launder clothing before re-use. Discoloration of the wetted skin caused by electrolyte contact will disappear after a few days. Yellow coloration of the skin by contact with some electrolytes will disappear within a month.

In the event of a fire, the organic parts of electrolytic capacitors may release such constituents as Nitrous Oxides and Carbon Monoxide through incomplete combustion.

DISPOSAL

Electrolytic capacitors are subject to special waste disposal regulations. Aluminum electrolytic capacitors are free from PCB- or PBDE-containing substances. However, because of other polluting ingredients, large quantities of electrolytic capacitors are subject to special waste regulations in accordance with applicable local and national laws.

Disposal of electrolytic capacitors must be in accordance with applicable environmental regulations.

Modern Electrolytic Capacitor Technology

General Series 3000

The ability of a capacitor to store electrical energy is a direct function of its mechanical geometry and its chemical composition. The amount of energy that it can store is given by the equation:

$$Q = CV$$

where Q = the magnitude of the stored charge
C = the capacitance in farads
V = the applied voltage

But the capacitance is determined by:

$$C = K\frac{a}{d}$$

where a is the directly opposing area of the plates, d is the distance between them (assumed to be uniform across the area), and K is the "dielectric constant" of the material separating them.

Engineers and scientists have been wrestling with these factors for generations, in the perennial effort to cram more and more capacitance into less and less space, in conformance with the unending trend of equipment miniaturization.

Obviously, increasing the area (a) of the capacitor plates will increase the capacitance of the device. This would tend to increase the size, but since only the area, not the thickness, of the plates is significant (in most applications) the plates could be made thinner to counteract the increase. Ways were developed to produce ever thinner metal foils, and eventually to deposit thin metallic films directly on both sides of a paper ribbon which can then be rolled up.

Reducing the thickness of the dielectric separator will also increase the capacitance of the device by reducing the distance (d) between the plates; this also reduces the size for a given capacitance, or allows more capacitance to be installed in a given space. Advancements in the production of high-quality, homogeneous plastic films of very thin gauges have enabled substantial reduction in capacitor size, combined with worthwhile increase in capacitance per volume.

Use of dielectric materials having higher dielectric constants will also increase the capacitance of the device, hopefully with a decrease (or at least no increase) in unit size. The search for better materials will continue.

One of the major breakthroughs in this field occurred about 85 years ago: the development of the electrolytic capacitor, a brillantly ingenious expedient for obtaining high capacitance in a small space. Essentially, it consisted of an aluminum-foil ribbon, on the surface of which a thin film of aluminum oxide has been formed electro-chemically, and a water-based electrolyte fluid which acts as the opposing plate. The oxide-coated foil, a second strip of aluminum foil, and a porous strip of paper interposed between them were rolled up together, and suspended in the liquid electrolytic, which penetrated the porous spacer. The physical relationship is diagrammed in Figure 1.

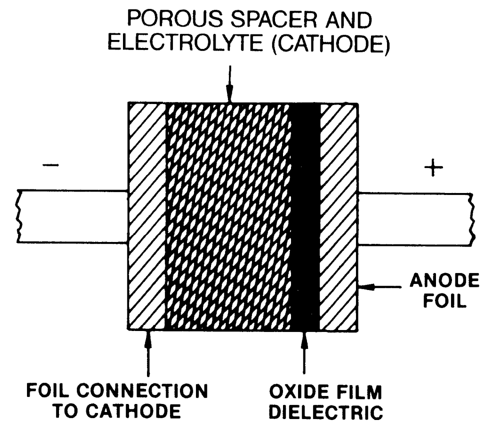


Fig. 1. Polarized Electrolytic Capacitor.

The oxide-coated foil is the positive plate (anode), the aluminum oxide film is the dielectric, and the fluid electrolyte is the negative plate (cathode). The second strip of aluminum foil serves only as a connection in broad and intimate contact with the negative-plate electrolyte, and is usually bonded to the aluminum can that houses the capacitor. The porous strip prevents direct short-circuits between the two foil strips.

The oxide dielecetric has a thickness on the order of 0.01 micron; thus the distance (d) between the "plates" has been reduced almost to the vanishing point. Furthermore, the dielectric constant (K) of this oxide is approximately 11. compared to 5 for paper, or 3 for polycarbonate or Mylar® plastic film. As a result, the capacitance per cubic inch in an electrolytic capacitor is increased tremendously, compared to conventional capacitor designs, even in the original electrolytic versions.

Modern Electrolytic Capacitor Technology

Over the years since their inception, there have been continuous improvements in electrolytic capacitor designs, and advancements in their technology. One of the most significant was that of etching the anode plate. The etching action exposes the grain structure, enormoulsy increasing the area of the surface for a given area of foil. Etching of a given area of aluminum foil results in a many fold increase in the actual surface area facing the electrolyte plate, in the finished capacitor. Two other notable advancements were the development of non-aqueous and solid electrolytes, and of practical manufacturing techniques for the production of high-purity aluminum foil. Both of these factors will be examined in detail later, in conjunction with capacitor fabrication.

While the energy storage capabilities of aluminum electrolytic capacitors are impressive, electrolytic construction has certain inherent limitations that affect the use and perfomance of these capacitors. Safe operating voltages are limited to about 450 volts. The oxide dielectric has rectifer porperties, blocking current flow in one direction but offering low resistance in the opposite direction; it is therefore limited to DC applications, and a voltage reversal of more than a volt or two will cause breakdown of the film and destruction of the capacitor. (Non-polarized types for AC applications are available. Their construction is essentially the same as shown in Figure 1, but both foils are coated with oxide dielectric, constituting two capacitors connected back to back). The power factor of electrolytics is considerably higher than those of other capacitor types, and the broad plate area makes for appreciable leakage.

Production Technology

The design and fabrication of an electrolytic capacitor is an extremely complex science. The physical principles involved, and their interlocking—and occasionally mutually exclusive—relationships have been the subject of continuous, heavy research for more than 80 years. Some of the developments that have evolved are discussed below.

The Anode (Positive Plate). Capacitance is directly proportional to the surface area of the capacitor plates. This factor has been uniquely exploited in electrolytic design by etching the surface of the anode foil, either chemically, by immersion in an acid bath such as hydrochloric acid, or electrochemically by immersion in a conductive, corrosive bath such as a solution of sodium chloride, and applying an electric current to the foil and solution. In both cases, the etching action exposes the grain structure of the metal, enormously increasing the area of the surface for a given area of foil. The degree of etch is controlled by immersion time in chemcial etching, and by the regulation of current flow in electrochemical etching.

The presence of impurities (principally copper, silicon, magnesium, iron and zinc), in the anode foil, can result in early failure of an electrolytic capacitor. Particles of other metals do not form an oxide barrier layer as aluminum does, hence constitute leakage paths. They also form galvanic couples with aluminum and will produce hydrogen gas in the presence of an electrolyte, besides reducing the efficiency of the oxide-layer barrier and causing generation of excessive heat. For these reasons, high-purity aluminum is used for foils, and the electrochemical etching process is the most suitable for use on this material. Lower-purity aluminum is used for the cathode foil.

In the electrochemical etching process, high etching-current density produces a fine etch pattern, with very high surface gain. However, when this surface is anodized (as discussed later) to voltages above 100 volts, the thickness of the oxide layer formed will bridge over some of the fine depressions of the etch pattern, reducing the surface gain, and the forming reaction will cause mechanical erosion of the peaks of the etch, further reducing the effective area.

Using the lower etching-current density produces a coarser surface, but the higher resistance to erosion and over-bridging results in a higher final capacity, when anodized at higher voltages. Thus, there is a trade-off relationship between etch coarseness and forming voltage in achieving maximum capacity at a selected working voltage, in a capacitor of given size. It is possible to custom-tailor the etch for optimum capacity at a given voltage.

The foil is run as a continuous ribbon through the precleaning bath, then over a roller which supplies the current for etching, then down into the etching tank, then through a series of baths that remove the etch solution, neutralize residual salt, remove loose metal particles, and wash away any remaining materials carried over from the processing tanks. The foil is then dried and immediately rolled, and protected from the atmosphere to prevent formation of "non-barrier" oxide prior to its entry into the anodizing, or forming, process.

Two types of "anodized" films can be formed on aluminum. In contact with moist air, the surface layer of aluminum forms a porous oxide of regular structure and low resistance, known as non-barrier oxide. When immersed in certain electrolyte solutions and connected to a DC power source as an anode with the solution as a cathode, the surface layer of aluminum forms an impervious, amorphous film of aluminum oxide having the property of restricting the flow of current in one direction and permitting it to flow in the opposite direction. This barrier oxide layer has a thickness which is a function of the applied voltage-approximately 14 angstroms per volt, at room temperature. The forming voltage must be considerably higher than the proposed operating voltage, to provide adequate dielectric strength over a long operating life despite aging effects. Leakage current increases rapidly as the operating voltage approaches the forming voltage value, particularly in "wet" electrolytics.

Needless to say, the foil, the electrolyte, and the tanks and apparatus must all be of the highest purity, and cleanliness. The presence of impurities can result in porosity in the oxide film, and can cause some dissolving of the film in the electrolyte—an effect that can double for every 10°C rise in the temperature of the solution. Impurities remaining in the elements of a finished capacitor will cause reactions that will result in high leakage, early deterioration, and outright failure after a short operating life.

The Electrolyte. In an electrolytic capacitor the electrolyte constitutes the second electrode, or plate, separated from the anode, or positive plate by this barrier layer of oxide formed on the anode surface. Ideally, it must be chemically inert, and have good temperature stability, and the proper conductivity. If the conductivity is too low, a high ESR (equivalent series resistance) results, with consequent high loss factor. If the conductivity is too high for the rated operating voltage, electrolytic breakdown in the form sparking occurs (known as "scintillation"), resulting in failure of the capacitor.

Wet electrolytic capacitors use a liquid electrolyte; the solvent (usually from the glycol family), some form of conductive salts, and a controlled amount of water. A porous ribbon of a nonconductive material such as a highly absorbent paper is wound as a separator between the two foils, and this ribbon is saturated with the electrolyte. The construction of such a capacitor is shown on Figure 2. The rolled element is installed in a cylindrical metal container which may be connected to the cathode foil. A plastic sleeve is provided on some types, to facilitate the use of off ground applications.

Limiting the amount of water in the electrolyte limits gassing and chemical activity, thereby increasing life expectancy. Low water levels in electrolytes also increase the shelf life. Using solvents less viscous than glycols, as an example amides, and more soluble salts, enables the electrolyte to penetrate into the fine etch structure of the foil more readily, thus contacting a greater surface area. This increases the ratio of unit capacitance to contact area and further reduces E.S.R.

The resistivity of electrolytes particularly with high water content, varies with temperature especially below 25°C. This results in high loss of capacitance and increase in E.S.R. at temperatures below −10°C. The high water content in electrolytes also limits their use to maximum temperature of +85°C. At these high temperatures they have limited life expectancy and shelf life. Local sites in the aluminum foil are activated by water, allowing exposure of bare metal. This results in high leakage current when a stored capacitor is subjected to applied voltage. If this leakage current can reach a sufficient magnitude from an unregulated source, the unit may go into thermal runaway, with subsequent failure.

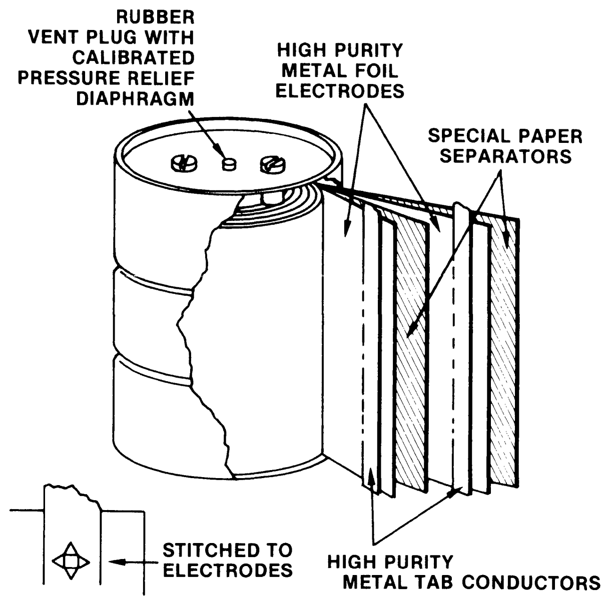


Fig. 2. Basic construction of a concentrically wound computer grade electrolytic capacitor.

At extremely low temperatures, conventional glycol family electrolytics lose in excess of 35% of their capacitance, and increase their E.S.R. manyfold, in relation to their room temperature values. These effects are caused by the increase in resistivity of the electrolyte, due to increased viscosity or sometimes by crystalization, as well as its shrinkage from the etch pattern of the foil. This results in poor contact between the electrolyte and the foils. This type of capacitor becomes a practically pure resistive device at +60°C due to these effects.

While it is a fact that amide based electrolytes produce capacitors with superior low temperature characteristics, such as an 80% capacitance retention at −55°C, they have several undesirable characteristics. The vapor pressures of amide base electrolytes are much higher than for glycols, thereby requiring superior sealing characteristics, and special materials in their containers. The high vapor pressures effect the long term life at high temperature operation. The toxicity of the amides is also considerably greater than glycols and they may also have adverse ecological effects.

Philips Components has developed non-aqueous, glycol family, electrolytes that possess excellent E.S.R. characteristics and superior, long term, high temperature operation. This is illustratred in Figure 4. This shows the superior E.S.R. stability of the glycol electrolyte vs the amide based on at 105°C operation.

Life Test Characteristics ESR @ 105°C DMF vs Glycol Low Volt Electrolyte.

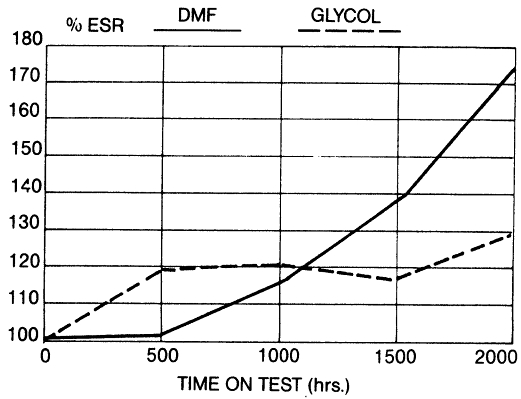


Fig. 3. E.S.R. Stability comparison at high temperature of amide vs. glycol base electrolytes.

While the low temperature characteristics are somewhat inferior, the following curves should indicate that they are quite acceptable for all but the most critical military applications.

Figure 4 illustrate typical low temperature operating characteristics with the newly developed and utilized electrolytes.

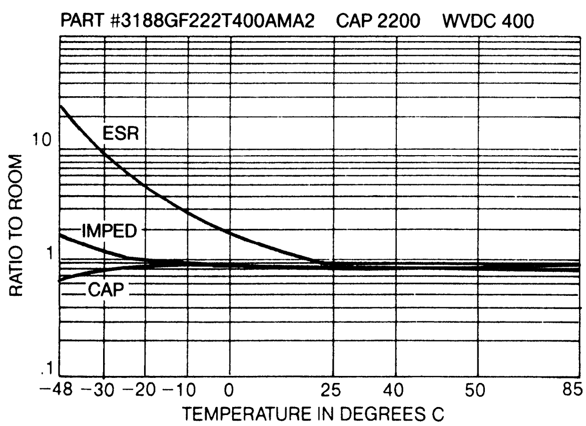


Fig. 4. Typical Low Temperature Operating Characteristics

The Spacer. The characteristics of the spacer that separates the foil ribbons influence the ESR of the capacitor. Each type of spacer has a resistance factor dependent upon its density, type of fiber, and fiber shape. In the design of low-ESR capacitors, it is essential to use spacers with low resistance factors. At present, the lowest resistance-factor spacers are of the lowest-density types, and since this low density is associated with minimum mechanical strength, special equipment is required to utilize them effectively. Proper design sometimes involves use of more than one spacer for optimum electrical characteristics and ease of manufacture. Figure 5 presents microphotographs of various spacers, showing their fiber structure.

The Cathode. The cathode foil in an electrolytic capacitor serves as a means of making extended contact with the electrolyte throughout the length and breadth of the separator strip. However, it also effectively forms another capacitor with the electrolyte, in series with the anode capacitor. The total effective capacitance is:

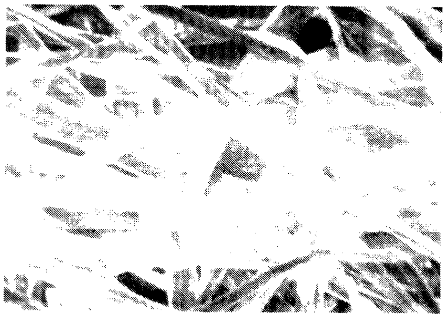
$$\frac{1}{C_{total}} = \frac{1}{C_{anode}} + \frac{1}{C_{cathode}}$$

Theoretically, the cathode foil has no insulation or oxide coating; its capacitance therefore should be infinitely large, and the total capacitance would be governed by the anode alone. Actually, a thin oxide film of some sort forms on the metal through exposure to the atmosphere and to the electrolyte, reducing this capacitance, though in all but low-voltage electrolytics it is considerably higher than the anode capacitance because of the relative thinness of the cathode film.

Non-polar electrolytic capacitors are essentially two capacitors connected back to back. Both foils are anodized to form oxide barrier layers, and they share the electrolyte in common. The system is inefficient, having a high power factor due to the large ESR, but is an effective and economical device in such AC applications as motor-starting capacitors where the intermittent use allows time for dissipation of generated heat between operations. The capacitor manufacturer is well equipped to advise a customer on his specification, and his application, to maximize performance and life at minimum cost, and to adjust his processes to produce the idealized capacitor.

Electro-Mechanical Considerations

Several mechanical innovations have been incorporated into electrolytic capacitor design, aimed at improving the electrical performance as well as the efficiency of these components. A very significant one is the multi-tabbing of the foil windings. Since the foil cross-section is extremely small, the foil resistance can be appreciable, especially in the larger-diameter units. An effective method for minimizing this resistance is to install several connection tabs at equal distances along the length of the foils. This has the effect of connecting the resistance of the segments in parallel, thereby reducing the total resistance of the foil ribbon, and lowering the ESR.



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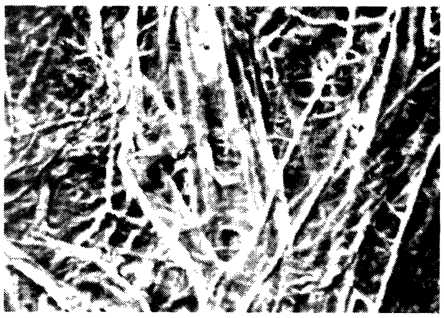

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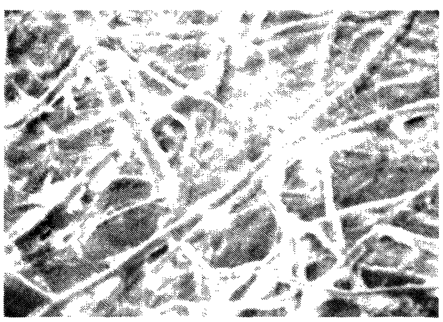

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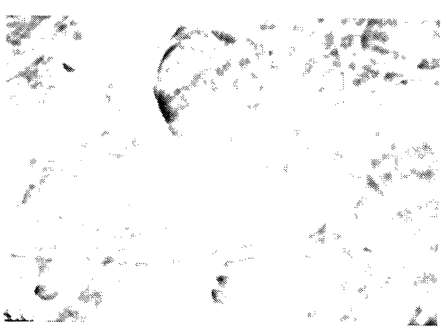

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Fig. 5. Fiber Stuctures of Spacers.

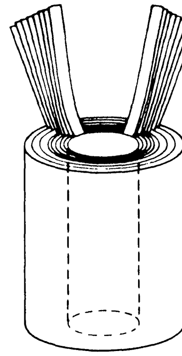


Fig. 6. Multi-Tabbed Doughnut-Wound Capacitor.

The coil helices of foil, being effectively in series with the conductive paths in the capacitor, also contribute some inductance to the ESL (equivalent seies inductance) of the unit. But multitabbing reduces this effect significantly, not only by connecting the inductances of the segments in parallel, but also by the bifilar action of the centered tabs. For most effectively minimizing ESR and ESL, the tabs must placed in the exact mathematical center of each segment; this placement is now accomplished by computerized techniques which locate the tab for optimum electrical performance, and for mechanical ease of assembly. Figure 6 shows this multi-tabbed construction; and Figure 7 shows typical characteristics achieved with this design. Capacitors of this construction can attain ESR values of less than 2 millliohms in the 120 HZ-40k Hz frequency range.

Another benefit of the multi-tabbing technique is greater realization of capacitance in high-capacitance, low-voltage units. Since the unit capacitance with its associated individual foil resistance is a strip-line network, reduction of this resistance increases the effective capacitance at the terminals of the device.

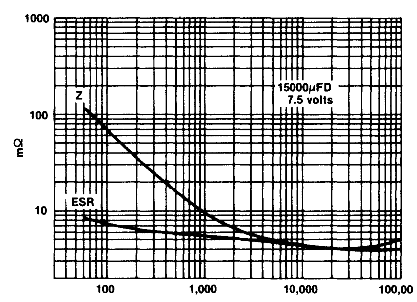


Fig. 7. Impedance and ESR vs. Frequency, PhilipsComponents High-Frequency Capacitor.

Another recent improvement is the elimination of potting compound. This is available on special order when a higher than standard vibration is a requirement. In previous designs, a bituminous compound was used to anchor the capacitor element in its metal case to prevent damage or failure due to mechanical vibration; this compound, being a poor thermal conductor, constituted a barrier to efficient heat dissipation from the element. Philips Components developed a method (patent pending) of crimping the sides of the case to achieve direct contact with the capacitor element as shown in Figure 8. This achieves a positive anchoring of the element, preventing its movement in any direction when subjected to vibration.

Direct and firm contact between case and element provides excellent thermal conductivity from the element to the ambient atmosphere and chassis or frame support, resulting in cooler operation of the capacitor. In addition, absence of potting material results in uniform gas expansion space in each unit, increasing the operating life of the capacitor. Units with this construction are the most suitable for mounting in any plane during operation.

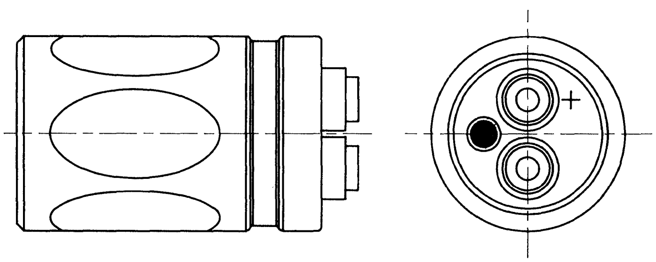


Fig. 8. Crimped Case.

Further enhancement of the thermal efficiency of the unit is achieved by winding the capacitor element with a large core opening. The development of foils with higher capacitance per unit area decreases the foil length required for a given capacitance rating. By keeping the outer diameter constant, for efficient roll contact with the case, and increasing the internal core size, a higher thermal efficiency is realized.

Definition of Capacitor Parameters

Electrically, an ideal capacitor exhibits only capacitance between its terminals—no resistance, no inductance—and when a varying voltage is applied, the current flowing in it will lead the voltage applied across it by 90°. In practical capacitors the situation is as shown in Figure 9, the lumped-parameter circuit for a capacitor. Because of its physical construction and composition, the capacitor unavoidably includes both inductance and resistance in series with the capacitance, and minute leakage paths through the dielectric add some resistance in parallel with the capacitance.

ESL, the "equivalent series inductance," is determined by the mechanical construction of the finished capacitor. ESR, the "equivalent series resistance," in an electrolytic capacitor is determined by the electrolyte, the spacer, the dielectric (barrier oxide), and the foil resistance. R_L, the DC resistance due to leakage current, is determined by the qualities of the dielectric. The actual values of these lumped parameters vary quite widely among electrolyte capacitors because of differences in size, and in forming techniques, as well as in construction and composition. In any given capacitor, they also vary with ambient conditions, and with applied voltage, waveform, and frequency. What is more, they often vary in a non-linear manner. For these reasons, capacitor parameters must often be qualified by stating range limitations and conditions of operation. This has some significant influences on the equipment designer's choice of a capacitor, and its performance in a particular application, as indicated in the following discussions.

Capacitance. The capacitance of an electrolytic capacitor is normally stated in microfarads, though the time is approaching when single units will offer one or more farads of capacitance in a container of practical size. The forming process used to establish operating voltage ratings is a precise science, but it is not yet exact. Therefore the actual capacitances achieved in capacitors of a particular production run will vary somewhat from unit to unit, and these units are cataloged within a liberal capacitance tolerance. Most applications for electrolytic capacitors are uncritical of exact capacitance values, and require only that the capacitance exceed a nominal minimum value.

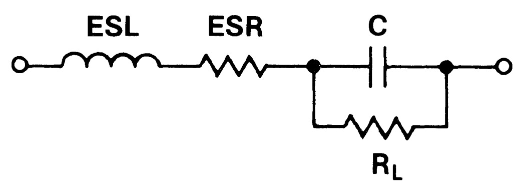


Fig. 9. Equivalent Circuit of a Practical Capacitor.

Capacitance Tolerance (Accuracy). This tolerance is stated as the maximum positive and negative deviations of the capacitance from a rated nominal value, at a standard test temperature (usually 25° ±3°C), measured at a standard frequency (usually 120 Hz), at a negligibly low test voltage (usually 1 volt). It is usually expressed as a percentage of nominal capacitance. Common tolerances are −10% +50%, −10% +75%, and ±20%. Closer tolerances are available on special order, for critical applications.

Notes: Measurements at other than the standard test temperature must allow for the temperature characteristic (see below) of the capacitor. "Negligibly low test voltage" means that the test voltage applied is not high enough to cause significant temperature rise due to losses and/or leakage. Usually at the standard test frequency, the test voltage is not critical.

Temperature Characteristic (of Capacitance). The variation of capacitance with temperature, in electrolytic capacitors, is non-linear, particularly in the region below room temperature. To list an over-all average numerical temperature coefficient would be misleading, since the coefficient is quite small at conventional operating temperatures, and substantially larger at low temperatures. Electrolytics are not ordinarily utilized in thermal-compensation or stabilization schemes, but their performance over a specific temperature range is usually of interest to the circuit designer, and their temperature characteristics are customarily provided in graphic form (see Figure 4 for typical examples of glycol vs. amide electrolytics).

The temperature characterisitc of capacitance for a given type or model electrolytic capacitor will vary with the nominal capacitance and voltage ratings.

Note: The temperature reference in this characteristic is that of the capacitor, not the ambient temperature.

DC Working Voltage. This is the maximum voltage at which a capacitor may be operated continuously, over its rated operating temperature range. Voltages in electronic and electrical circuits are often DC with an additional AC component consisting of ripple or noise signals, fluctuations due to power-line variations, etc. The specified DC working voltage rating includes the total (DC plus peak AC) voltage that may be applied in continuous operation. The AC component must not be allowed to exceed the DC component, to avoid polarity reversal and possible destruction of the capacitor.

Surge Voltage. Electrolytic capacitors can usually withstand an occasional brief pulse or surge of voltage beyond their rated DC working voltage without being damaged. A surge rating is established for each type or model, which includes ripple, noise, power-line fluctuations and all transient occurrences. This rating is on a non-recurrent basis, and should never be exceeded, even momentarily.

Equivalent Series Resistance (ESR). The ESR of a capacitor is a standard characteristic, expressed in ohms, representing all energy losses in the "equivalent " series resistance of a capacitor, regardless of source: lead resistance, termination losses, dissipation in the dielectric material, foil resistance. It assumes that all losses can be represented by a single resistance in series with the idealized perfect capacitor. The power losses caused by it result in internal heating of the device, which in turn affects the useful expected life, the impedance (a major factor in applications), and the permissible ripple current.

ESR is strongly dependent upon the operating temperature of the capacitor, and varies inversely with it as can be seen in Figure 4. This variance is primarily the result of the contribution of the electrolyte—spacer combination to the total ESR of the capacitor.

An added source of ESR is found in the resistance of the aluminum foil itself, due to both the series resistance of the foil and the resistance of the oxide on the anode foil. The higher voltage ratings will have higher ESR values due to thicker anodic oxide films.

Since in large capacitors the length of the foil ribbon is considerable, and the actual cross-section of the foil is relatively thin due to the etching of the surfaces, significant resistance exists. This resistance is further affected by the individual etch patterns used, but may be controlled to some extent by adjusting the foil area-to-capacitance ratios; that is, the higher the ratio of foil area to unit capacitance, the lower the ESR produced.

Effective Series Inductance. The effective series inductance of a capacitor, which is a function of its mechanical construction, dominates the impedance of the device above the self resonant frequency. This can become a limiting factor in higher frequency applications such as switch mode power supplies. The self resonance of the capacitor is that frequency at which the inductive reactance and the capacitive reactance are equal in magnitude and opposite in phase. At this frequency the impedance of the device is equal to the ESR.

Ripple Current. When a periodic (AC) voltage wave is superimposed the DC voltage applied to an electrolytic capacitor—i.e., when the filter capacitor in a DC power supply is being charged by the rectifier and discharged by the external load—current flows into and out of the capacitor. This "ripple current" flows through the ESR of the capacitor, generating heat which increases the internal temperature of the unit.

Being an electrochemical device, the capacitor is subject to deterioration, including a shortened life, by temperature increases. The higher temperatures cause an increase in leakage current, and loss of electrolyte through the seals; the current flow initiates electrolysis of the electrolyte, generating gas, and decreasing the quantity of electrolyte, which in turn causes a decrease in capacitance and an increase in ESR. The failure mode typically is a loss of capacitance to the point that the power supply ripple voltage will be beyond the specified limit.

Ripple current through the capacitor can be measured in several ways, some more accurate than others. Figure 18 illustrates three of these methods. The first method shown is the most accurate. The current is read directly from a True RMS current probe. The second method, reading the RMS voltage across a very-low-resistance shunt and using Ohms' Law to derive the current works very well, if the resistance of the shunt is less than 10% of the impedance of the capacitor. The third method is perhaps the easiest, but is the least accurate if the actual impedance of the capacitor is not known. The ripple current can be approximated by dividing the RMS voltage by the calculated impedance:

$$Z_C = \sqrt{ESR^2 + (X_L - X_C)^2}$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi fL$$

f = frequency, C = Farads, L = Henries

where the ESR, capacitance, and inductance are the values specified in the manufacturer's literature.

Quality, Dissipation, and Power Factors. These three factors are discussed together because they are interrelated, and are sometimes misinterpreted when described individually. Quality Factor (or Q) is simply the ratio of the capacitor's reactance to its resistance (X_C/R) at a specified frequency. It should be as high as possible, since a lower ratio indicates higher power loss. Dissipation Factor (DF) is the reciprocal of Quality Factor: $DF = 1/Q = R/X_C$. It should be as low as possible, since high DF represents a high power loss. Power Factor (PF) is the ratio of resistance to impedance (R/Z) and represents the fraction of input voltamperes (or power) dissipated in the capacitor. Quality Factor and Dissipation Factor are terms associated with DC capacitors. Power Factor is primarily associated with AC motor start capacitors.

Insulation Resistance and DC Leakage Current. I_R is a measure of the capacitor's ability to retain a charge with respect to time. It is the ratio of the DC test voltage impressed across to the current that flows through it (at a specified voltage and temperature). This current is measured 5 minutes after the capacitor has been charged to the test voltage. The capacitor then appears as a high resistance in parallel with an ideal (non-leaky) capacitor. Insulation resistance is sometimes expressed in megohms for small capacitors and as a time constant (the product of R and C in megohm-microfarads) for higher-value capacitors. It should not be confused with the equivalent series resistance.

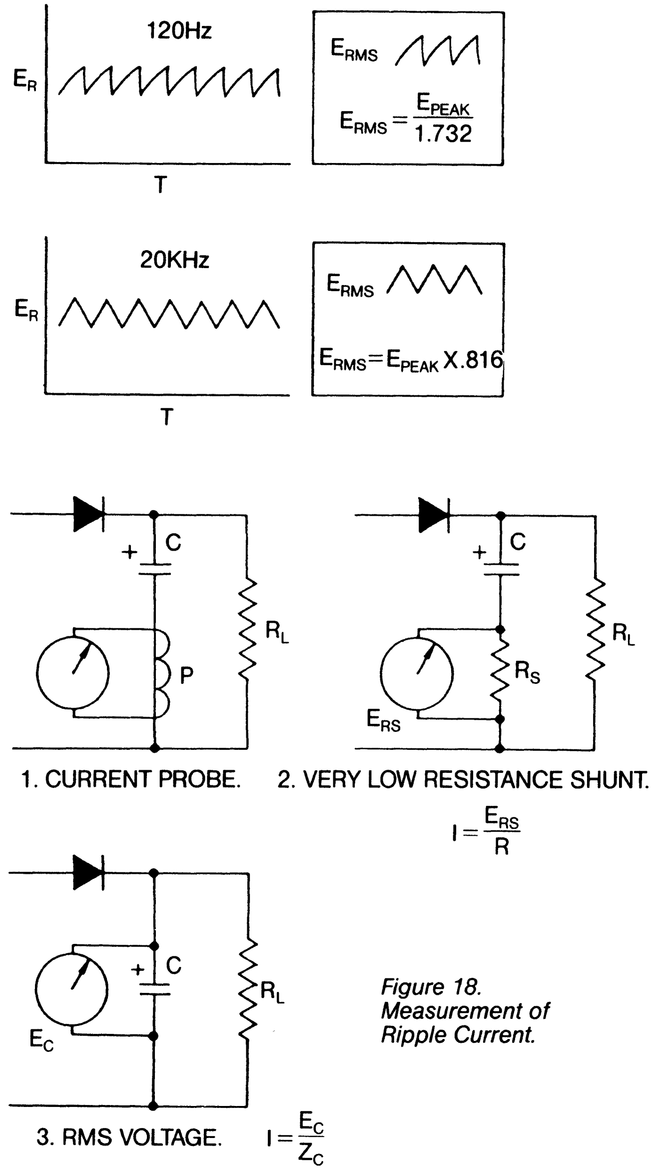
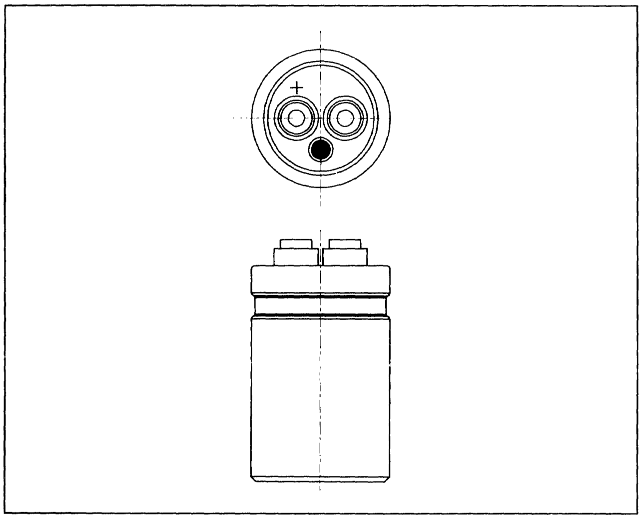


Figure 18. Measurement of Ripple Current.



Computer-Grade Aluminum Electrolytic Capacitors

Description

Philips Components' Series 3186 Computer-Grade Aluminum Electrolytic Capacitors are designed for use in the most demanding data-system and industrial-control applications. They provide the highest attainable reliability in this class of capacitors, with generous safety margins insured by computer designing and painstaking manufacturing control.

This family of capacitors offers the widest range of capacity/voltage combinations ever offered in heavy-duty computer-grade electrolytics. Combined with 39 standard case sizes and five terminal options, the Series 3186 Capacitors can provide a suitable standard product for nearly every application. In addition, the ripple-current ratings for these units meet or exceed all industry requirements for similar products. These capacitors are suitable for all applications where long life at high operating temperatures without derating is required in a standard computer-grade product.

Features

- 2000 Hours Operating Life at 85°C.
- Highest Capacitance per case size.
- Meets or exceeds all requirements for EIA-RS395 for type II capacitors.
- Computer-designed for optimum performance.
- 39 Standard Case Sizes.
- Pressure-Sensitive Safety Vent.
- Operating Temperature: −40°C +85°C.
- Termination: Screw Terminals.
- Voltage Range 6.3-450 VDC.

Performance Characteristics: See page 95
Life Prediction Guidelines: See page 99
Application Guidelines: See page 105

How to Specify

Philips Components Series Capacitors can be completely specified using the following designation:

XXXX BA 942 U 005 A M A-1

- **XXXX** — Philips Components Product Series
- **BA** — Case Size Code
- **942** — Capacitance
  XX = Significant Digits
  X = Multiplier
  i.e. 942 = 9400μF
- **U** — Tolerance
  U = −10%+75%
  T = −10%+50%
- **005** — Voltage
  005 = 5VDC
  050 = 50VDC
- **A** — Terminal Style
  A = High Post
  B = Low Post
  D = High Current
  H = PC Mount
- **M** — Insulation & Bracket Code (see physical spec)
- **A-1** — Factory Assigned Number

Physical Specifications Computer Grade

Insulated Case Dimension Adder And Bracket Codes

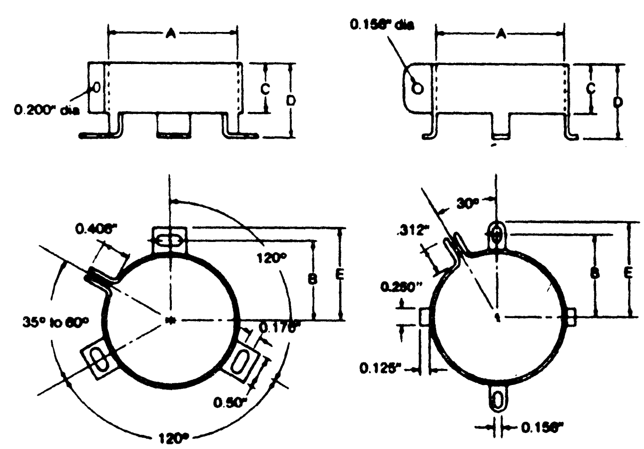
Insulation Type	Inches D	Inches L	Inches H	mm D	mm L	mm H	Bracket Code without	Bracket Code with
.004 inch Polymeric	.010	.015	.010	.25	.38	.25	M	L
.008 inch Polymeric	.020	.032	.024	.508	.813	.61	P	R
.012 inch Polymeric	.025	.062	.045	.63	1.58	1.14	H	J
Uninsulated	—	—	—	—	—	—	N	X

Bracket Dimensions

Case Diameters	A ±0.005	B ±0.031	C ±0.016	D ±0.031	E ±0.031
	Dimensions in Inches				
1.375	1.375	0.906	0.562	0.750	1.156
1.750	1.750	1.125	0.750	1.125	1.313
2.000	2.000	1.250	0.750	1.125	1.438
2.500	2.500	1.500	0.750	1.125	1.688
3.000	3.000	1.750	0.750	1.125	1.938

Case Diameters	A ±0.13	B ±0.79	C ±0.40	D ±0.79	E ±0.79
	Dimensions in Millimeters				
34.92	34.92	23.01	14.25	19.05	29.36
44.45	44.45	28.57	19.05	28.57	33.35
50.80	50.80	31.75	19.05	28.57	36.51
63.50	63.50	38.10	19.05	28.57	42.87
76.20	76.20	44.45	19.05	28.57	49.22

Bracket Outline Drawing



For 1-3/4(D), 2(E), 2-1/2(F), and 3(G) inch diameter can sizes

For 1-3/8(B) inch diameter can sizes

Physical Specifications Computer Grade

Dimensions

Case Code*	Uninsulated Case Dimensions: Dimensions in Inches D	L	S	Dimensions in Millimeters D	L	S
BA	1.375	2.125	.500	34.92	53.97	12.70
BB	1.375	2.625	.500	34.92	66.67	12.70
BC	1.375	3.125	.500	34.92	79.37	12.70
BD	1.375	3.625	.500	34.92	92.07	12.70
BE	1.375	4.125	.500	34.92	104.77	12.70
BF	1.375	4.625	.500	34.92	117.47	12.70
BG	1.375	5.125	.500	34.92	130.17	12.70
BH	1.375	5.625	.500	34.92	142.87	12.70
DA	1.750	2.125	.750	44.45	53.97	19.05
DB	1.750	2.625	.750	44.45	66.67	19.05
DC	1.750	3.125	.750	44.45	79.37	19.05
DD	1.750	3.625	.750	44.45	92.07	19.05
DE	1.750	4.125	.750	44.45	104.77	19.05
DF	1.750	4.625	.750	44.45	117.47	19.05
DG	1.750	5.125	.750	44.45	130.17	19.05
DH	1.750	5.625	.750	44.45	142.87	19.05
EA	2.000	2.125	.875	50.80	53.97	22.22
EB	2.000	2.625	.875	50.80	66.67	22.22
EC	2.000	3.125	.875	50.80	79.37	22.22
ED	2.000	3.625	.875	50.80	92.07	22.22
EE	2.000	4.125	.875	50.80	104.77	22.22
EF	2.000	4.625	.875	50.80	117.47	22.22
EG	2.000	5.125	.875	50.80	130.17	22.22
EH	2.000	5.625	.875	50.80	142.87	22.22
FB	2.500	2.625	1.125	63.50	66.67	28.57
FC	2.500	3.125	1.125	63.50	79.37	28.57
FD	2.500	3.625	1.125	63.50	92.07	28.57
FE	2.500	4.125	1.125	63.50	104.77	28.57
FF	2.500	4.625	1.125	63.50	117.47	28.57
FG	2.500	5.125	1.125	63.50	130.17	28.57
FH	2.500	5.625	1.125	63.50	142.87	28.57
GC	3.000	3.125	1.250	76.20	79.37	31.75
GD	3.000	3.625	1.250	76.20	92.07	31.75
GE	3.000	4.125	1.250	76.20	104.77	31.75
GF	3.000	4.625	1.250	76.20	117.47	31.75
GG	3.000	5.125	1.250	76.20	130.17	31.75
GH	3.000	5.625	1.250	76.20	142.87	31.75
GJ	3.000	5.875	1.250	76.20	149.22	31.75
GN	3.000	8.625	1.250	76.20	219.07	31.75

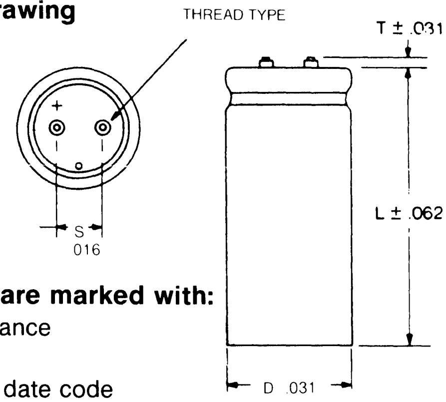
PC Mount Overall Height (Inches)

Case Length	H
2.125	2.31
2.625	2.81
3.125	3.31
3.625	3.81
4.125	4.31
4.625	4.81
5.125	5.31
5.625	5.81

PC Mount Terminal Spacing (Inches)

Case Diameter	X	Y	Z
1.375	.550	.500	.375
1.750	.900	.700	.525
2.000	1.000	.800	.575

Case Outline Drawing

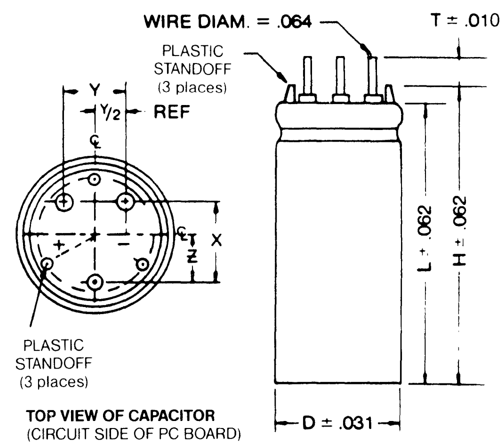


The capacitors are marked with:

- nominal capacitance
- rated voltage
- EIA source and date code
- maximum ambient temperature
- polarity
- name of manufacturer
- part number
- capacitance tolerance

Case Outline Drawing

PRINTED CIRCUIT BOARD MOUNT



Terminal Styles, Dimensions, and Code				
Terminal Style	**T (inches)**	**T (mm)**	**Code**	**Thread Type**
High Post	.250	6.4	A	10-32
Low Post	.063	1.6	B	10-32
High Current*	.093	3.2	D	¼-28
PC Mount**	.250	6.4	H	N/A

*Available in 2½″ and 3″ diameter cans only. Recommended for applications where ripple current exceeds 30 Amperes.
**Contact factory for maximum capacitance.
EA can only multiply .8 time capacitance table.

6.5 VDC Working 9.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
57000	3186BA573U6P5AP	1.375 × 2.125	0.0129	7.5
68000	3186BB683U6P5AP	1.375 × 2.625	0.0111	8.8
91000	3186BC913U6P5AP	1.375 × 3.125	0.0088	10.6
110000	3186BD114U6P5AP	1.375 × 3.625	0.0076	12.2
130000	3186BE134U6P5AP	1.375 × 4.125	0.0067	13.6
160000	3186BF164U6P5AP	1.375 × 4.625	0.0060	15.1
180000	3186BG184U6P5AP	1.375 × 5.125	0.0056	16.4
200000	3186BH204U6P5AP	1.375 × 5.625	0.0053	17.5
100000	3186DA104U6P5AP	1.750 × 2.125	0.0084	10.9
120000	3186DB124U6P5AP	1.750 × 2.625	0.0072	12.6
160000	3186DC164U6P5AP	1.750 × 3.125	0.0058	15.1
200000	3186DD204U6P5AP	1.750 × 3.625	0.0049	17.3
240000	3186DE244U6P5AP	1.750 × 4.125	0.0044	19.4
280000	3186DF284U6P5AP	1.750 × 4.625	0.0040	21.2
320000	3186DG324U6P5AP	1.750 × 5.125	0.0038	23.0
360000	3186DH364U6P5AP	1.750 × 5.625	0.0036	24.6
130000	3186EA134U6P5AP	2.000 × 2.125	0.0064	13.6
150000	3186EB154U6P5AP	2.000 × 2.625	0.0056	15.7
210000	3186EC214U6P5AP	2.000 × 3.125	0.0044	18.7
260000	3186ED264U6P5AP	2.000 × 3.625	0.0038	21.4
310000	3186EE314U6P5AP	2.000 × 4.125	0.0034	23.9
370000	3186EF374U6P5AP	2.000 × 4.625	0.0031	26.2
420000	3186EG424U6P5AP	2.000 × 5.125	0.0029	28.2
470000	3186EH474U6P5AP	2.000 × 5.625	0.0028	30.0
260000	3186FB264U6P5AP	2.500 × 2.625	0.0037	22.2
350000	3186FC354U6P5AP	2.500× 3.125	0.0030	26.3
440000	3186FD444U6P5AP	2.500 × 3.625	0.0026	29.9
530000	3186FE534U6P5DP	2.500 × 4.125	0.0023	33.2
610000	3186FF614U6P5DP	2.500 × 4.625	0.0021	36.2
700000	3186FG704U6P5DP	2.500 × 5.125	0.0020	39.0
790000	3186FH794U6P5DP	2.500 × 5.625	0.0019	41.5
520000	3186GC524U6P5DP	3.000 × 3.125	0.0023	33.7
650000	3186GD654U6P5DP	3.000 × 3.625	0.0020	38.3
780000	3186GE784U6P5DP	3.000 × 4.125	0.0018	42.3
910000	3186GF914U6P5DP	3.000 × 4.625	0.0016	45.0
1000000	3186GG105U6P5DP	3.000 × 5.125	0.0015	45.0
1100000	3186GH115U6P5DP	3.000 × 5.625	0.0015	45.0
1900000	3186GN195U6P5DP	3.000 × 8.625	0.0013	45.0

10.0 VDC Working 12.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
44000	3186BA443U010AP	1.375 × 2.125	0.0131	7.4
53000	3186BB533U010AP	1.375 × 2.625	0.0113	8.7
71000	3186BC713U010AP	1.375 × 3.125	0.0089	10.5
89000	3186BD893U010AP	1.375 × 3.625	0.0076	12.1
100000	3186BE104U010AP	1.375 × 4.125	0.0068	13.5
120000	3186BF124U010AP	1.375 × 4.625	0.0062	14.9
140000	3186BG144U010AP	1.375 × 5.125	0.0057	16.3
160000	3186BH164U010AP	1.375 × 5.625	0.0054	17.5
79000	3186DA793U010AP	1.750 × 2.125	0.0085	10.8
95000	3186DB953U010AP	1.750 × 2.625	0.0073	12.6
120000	3186DC124U010AP	1.750 × 3.125	0.0059	15.0
150000	3186DD154U010AP	1.750 × 3.625	0.0050	17.2
190000	3186DE194U010AP	1.750 × 4.125	0.0044	19.3
220000	3186DF224U010AP	1.750 × 4.625	0.0041	21.2
250000	3186DG254U010AP	1.750 × 5.125	0.0038	22.9
280000	3186DH284U010AP	1.750 × 5.625	0.0036	24.5
100000	3186EA104U010AP	2.000 × 2.125	0.0088	11.6
120000	3186EB124U010AP	2.000 × 2.625	0.0076	13.4
160000	3186EC164U010AP	2.000 × 3.125	0.0061	16.0
200000	3186ED204U010AP	2.000 × 3.625	0.0052	18.3
240000	3186EE244U010AP	2.000 × 4.125	0.0046	20.5
280000	3186EF284U010AP	2.000 × 4.625	0.0042	22.4
330000	3186EG334U010AP	2.000 × 5.125	0.0039	24.2
370000	3186EH374U010AP	2.000 × 5.625	0.0037	25.9
200000	3186FB204U010AP	2.500 × 2.625	0.0046	19.9
270000	3186FC274U010AP	2.500 × 3.125	0.0037	23.6
340000	3186FD344U010AP	2.500 × 3.625	0.0032	26.9
410000	3186FE414U010AP	2.500 × 4.125	0.0028	29.9
480000	3186FF484U010DP	2.500 × 4.625	0.0026	32.7
550000	3186FG554U010DP	2.500 × 5.125	0.0024	35.2
620000	3186FH624U010DP	2.500 × 5.625	0.0023	37.5
400000	3186GC404U010DP	3.000 × 3.125	0.0027	31.1
500000	3186GD504U010DP	3.000 × 3.625	0.0023	35.3
610000	3186GE614U010DP	3.000 × 4.125	0.0021	39.1
710000	3186GF714U010DP	3.000 × 4.625	0.0019	42.6
810000	3186GG814U010DP	3.000 × 5.125	0.0018	45.0
910000	3186GH914U010DP	3.000 × 5.625	0.0017	45.0
1500000	3186GN155U010DP	3.000 × 8.625	0.0015	45.0

15.0 VDC Working 18.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
32000	3186BA323U015AP	1.375 × 2.125	0.0134	7.4
38000	3186BB383U015AP	1.375 × 2.625	0.0115	8.6
51000	3186BC513U015AP	1.375 × 3.125	0.0091	10.4
64000	3186BD643U015AP	1.375 × 3.625	0.0077	12.0
76000	3186BE763U015AP	1.375 × 4.125	0.0068	13.5
89000	3186BF893U015AP	1.375 × 4.625	0.0062	14.9
100000	3186BG104U015AP	1.375 × 5.125	0.0058	16.1
110000	3186BH114U015AP	1.375 × 5.625	0.0055	17.3
56000	3186DA563U015AP	1.750 × 2.125	0.0137	8.5
68000	3186DB683U015AP	1.750 × 2.625	0.0117	9.9
91000	3186DC913U015AP	1.750 × 3.125	0.0093	11.9
110000	3186DD114U015AP	1.750 × 3.625	0.0080	13.7

15.0 VDC Working 18.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
130000	3186DE134U015AP	1.750 × 4.125	0.0071	15.3
150000	3186DF154U015AP	1.750 × 4.625	0.0064	16.8
180000	3186DG184U015AP	1.750 × 5.125	0.0060	18.2
200000	3186DH204U015AP	1.750 × 5.625	0.0056	19.5
73000	3186EA733U015AP	2.000 × 2.125	0.0089	11.5
88000	3186EB883U015AP	2.000 × 2.625	0.0077	13.4
110000	3186EC114U015AP	2.000 × 3.125	0.0062	15.9
140000	3186ED144U015AP	2.000 × 3.625	0.0053	18.2
170000	3186EE174U015AP	2.000 × 4.125	0.0047	20.3
200000	3186EF204U015AP	2.000 × 4.625	0.0043	22.3
230000	3186EG234U015AP	2.000 × 5.125	0.0040	24.1
260000	3186EH264U015AP	2.000 × 5.625	0.0038	25.7
140000	3186FB144U015AP	2.500 × 2.625	0.0062	17.2
190000	3186FC194U015AP	2.500× 3.125	0.0050	20.4
240000	3186FD244U015AP	2.500 × 3.625	0.0042	23.3
290000	3186FE294U015AP	2.500 × 4.125	0.0038	26.0
340000	3186FF344U015AP	2.500 × 4.625	0.0034	28.4
390000	3186FG394U015DP	2.500 × 5.125	0.0032	30.7
440000	3186FH444U015DP	2.500 × 5.625	0.0030	32.7
290000	3186GC294U015AP	3.000 × 3.125	0.0033	28.0
360000	3186GD364U015DP	3.000 × 3.625	0.0029	31.9
430000	3186GE434U015DP	3.000 × 4.125	0.0025	35.4
500000	3186GF504U015DP	3.000 × 4.625	0.0023	38.6
580000	3186GG584U015DP	3.000 × 5.125	0.0022	41.5
650000	3186GH654U015DP	3.000 × 5.625	0.0021	44.2
1000000	31860N105U015DP	3.000 × 3.625	0.0018	45.0

25.0 VDC Working 30.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
20000	3186BA203U025AP	1.375 × 2.125	0.0350	4.6
24000	3186BB243U025AP	1.375 × 2.625	0.0298	5.4
33000	3186BC333U025AP	1.375 × 3.125	0.0233	6.5
41000	3186BD413U025AP	1.375 × 3.625	0.0196	7.6
49000	3186BE493U025AP	1.375 × 4.125	0.0171	8.5
57000	3186BF573U025AP	1.375 × 4.625	0.0154	9.5
66000	3186BG663U025AP	1.375 × 5.125	0.0141	10.3
74000	3186BH743U025AP	1.375 × 5.625	0.0132	11.2
36000	3186DA363U025AP	1.750 × 2.125	0.0167	7.7
44000	3186DB443U025AP	1.750 × 2.625	0.0143	9.0
58000	3186DC583U025AP	1.750 × 3.125	0.0113	10.8
73000	3186DD733U025AP	1.750 × 3.625	0.0095	12.5
88000	3186DE883U025AP	1.750 × 4.125	0.0083	14.1
100000	3186DF104U025AP	1.750 × 4.625	0.0075	15.5
110000	3186DG114U025AP	1.750 × 5.125	0.0069	16.9
130000	3186DH134U025AP	1.750 × 5.625	0.0065	18.2
47000	3186EA473U025AP	2.000 × 2.125	0.0107	10.5
57000	3186EB573U025AP	2.000 × 2.625	0.0092	12.2
76000	3186EC763U025AP	2.000 × 3.125	0.0073	14.6
95000	3186ED953U025AP	2.000 × 3.625	0.0061	16.9
110000	3186EE114U025AP	2.000 × 4.125	0.0054	18.9
130000	3186EF134U025AP	2.000 × 4.625	0.0049	20.8
150000	3186EG154U025AP	2.000 × 5.125	0.0045	22.5
170000	3186EH174U025AP	2.000 × 5.625	0.0043	24.2
95000	3186FB953U025AP	2.500 × 2.625	0.0075	15.6
120000	3186FC124U025AP	2.500 × 3.125	0.0060	18.6

25.0 VDC Working 30.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
150000	3186FD154U025AP	2.500 × 3.625	0.0051	21.3
190000	3186FE194U025AP	2.500 × 4.125	0.0044	23.9
220000	3186FF224U025AP	2.500 × 4.625	0.0040	26.3
250000	3186FG254U025AP	2.500 × 5.125	0.0037	28.5
280000	3186FH284U025DP	2.500 × 5.625	0.0035	30.5
180000	3186GC184U025AP	3.000 × 3.125	0.0040	25.5
230000	3186GD234U025AP	3.000 × 3.625	0.0034	29.2
280000	3186GE284U025DP	3.000 × 4.125	0.0030	32.6
320000	3186GF324U025DP	3.000 × 4.625	0.0027	35.7
370000	3186GG374U025DP	3.000 × 5.125	0.0025	38.6
420000	3186GH424U025DP	3.000 × 5.625	0.0024	41.4
700000	3186GN704U025DP	3.000 × 8.625	0.0019	45.0

40.0 VDC Working 50.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
12000	3186BA123U040AP	1.375 × 2.125	0.0360	4.5
15000	3186BB153U040AP	1.375 × 2.625	0.0306	5.3
20000	3186BC203U040AP	1.375 × 3.125	0.0239	6.4
25000	3186BD253U040AP	1.375 × 3.625	0.0200	7.5
31000	3186BE313U040AP	1.375 × 4.125	0.0174	8.5
36000	3186BF363U040AP	1.375 × 4.625	0.0157	9.4
41000	3186BG413U040AP	1.375 × 5.125	0.0144	10.2
46000	3186BH463U040AP	1.375 × 5.625	0.0134	11.1
22000	3186DA223U040AP	1.750 × 2.125	0.0172	7.6
27000	3186DB273U040AP	1.750 × 2.625	0.0147	8.9
36000	3186DC363U040AP	1.750 × 3.125	0.0116	10.7
45000	3186DD453U040AP	1.750 × 3.625	0.0097	12.4
55000	3186DE553U040AP	1.750 × 4.125	0.0085	13.9
64000	3186DF643U040AP	1.750 × 4.625	0.0077	15.4
73000	3186DG733U040AP	1.750 × 5.125	0.0071	16.7
82000	3186DH823U040AP	1.750 × 5.625	0.0066	18.0
29000	3186EA293U040AP	2.000 × 2.125	0.0196	7.8
35000	3186EB353U040AP	2.000 × 2.625	0.0167	9.1
47000	3186EC473U040AP	2.000 × 3.125	0.0131	10.9
59000	3186ED593U040AP	2.000 × 3.625	0.0110	12.6
71000	3186EE713U040AP	2.000 × 4.125	0.0096	14.2
83000	3186EF833U040AP	2.000 × 4.625	0.0086	15.7
95000	3186EG953U040AP	2.000 × 5.125	0.0079	17.1
100000	3186EH104U040AP	2.000 × 5.625	0.0074	18.4
59000	3186FB593U040AP	2.500 × 2.625	0.0119	12.4
79000	3186FC793U040AP	2.500× 3.125	0.0093	14.9
99000	3186FD993U040AP	2.500 × 3.625	0.0078	17.1
110000	3186FE114U040AP	2.500 × 4.125	0.0069	19.2
130000	3186FF134U040AP	2.500 × 4.625	0.0062	21.2
150000	3186FG154U040AP	2.500 × 5.125	0.0056	23.1
170000	3186FH174U040AP	2.500 × 5.625	0.0053	24.8
110000	3186GC114U040AP	3.000 × 3.125	0.0053	22.1
140000	3186GD144U040AP	3.000 × 3.625	0.0045	25.4
170000	3186GE174U040AP	3.000 × 4.125	0.0039	28.4
200000	3186GF204U040DP	3.000 × 4.625	0.0035	31.2
230000	3186GG234U040DP	3.000 × 5.125	0.0033	33.9
260000	3186GH264U040DP	3.000 × 5.625	0.0031	36.3
430000	3186GN434U040DP	3.000 × 8.625	0.0025	45.0

50.0 VDC Working 65.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
9900	3186BA992U050AP	1.375 × 2.125	0.0365	4.5
11000	3186BB113U050AP	1.375 × 2.625	0.0312	5.2
15000	3186BC153U050AP	1.375 × 3.125	0.0244	6.4
19000	3186BD193U050AP	1.375 × 3.625	0.0204	7.4
23000	3186BE233U050AP	1.375 × 4.125	0.0177	8.4
27000	3186BF273U050AP	1.375 × 4.625	0.0159	9.3
31000	3186BG313U050AP	1.375 × 5.125	0.0146	10.2
35000	3186BH353U050AP	1.375 × 5.625	0.0136	11.0
17000	3186DA173U050AP	1.750 × 2.125	0.0176	7.5
21000	3186DB213U050AP	1.750 × 2.625	0.0150	8.8
28000	3186DC283U050AP	1.750 × 3.125	0.0118	10.6
35000	3186DD353U050AP	1.750 × 3.625	0.0099	12.3
42000	3186DE423U050AP	1.750 × 4.125	0.0086	13.8
49000	3186DF493U050AP	1.750 × 4.625	0.0078	15.3
56000	3186DG563U05APP	1.750 × 5.125	0.0072	16.6
63000	3186DH633U050AP	1.750 × 5.625	0.0067	17.9
22000	3186EA223U050AP	2.000 × 2.125	0.0199	7.7
27000	3186EB273U050AP	2.000 × 2.625	0.0169	9.0
36000	3186EC363U050AP	2.000 × 3.125	0.0133	10.8
45000	3186ED453U050AP	2.000 × 3.625	0.0111	12.5
54000	3186EE543U050AP	2.000 × 4.125	0.0097	14.1
64000	3186EF643U050AP	2.000 × 4.625	0.0087	15.6
73000	3186EG733U050AP	2.000 × 5.125	0.0080	17.0
82000	3186EH823U050AP	2.000 × 5.625	0.0075	18.3
45000	3186FB453U050AP	2.500 × 2.625	0.0121	12.3
61000	3186FC613U050AP	2.500 × 3.125	0.0094	14.8
76000	3186FD763U050AP	2.500 × 3.625	0.0079	17.0
91000	3186FE913U050AP	2.500 × 4.125	0.0069	19.1
100000	3186FF104U050AP	2.500 × 4.625	0.0062	21.1
120000	3186FG124U050AP	2.500 × 5.125	0.0057	23.0
130000	3186FH134U050AP	2.500 × 5.625	0.0053	24.7
90000	3186GC903U050AP	3.000 × 3.125	0.0076	18.6
110000	3186GD114U050AP	3.000 × 3.625	0.0064	21.4
130000	3186GE134U050AP	3.000 × 4.125	0.0055	24.0
150000	3186GF154U050AP	3.000 × 4.625	0.0050	26.4
180000	3186GG184U050AP	3.000 × 5.125	0.0046	28.7
200000	3186GH204U050DP	3.000 × 5.625	0.0042	30.8
330000	3186GN334U050DP	3.000 × 8.625	0.0033	41.4

63.0 VDC Working 85.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
6800	3186BA682U063AP	1.375 × 2.125	0.0376	4.4
8200	3186BB822U063AP	1.375 × 2.625	0.0320	5.2
10000	3186BC103U063AP	1.375 × 3.125	0.0252	6.3
13000	3186BD133U063AP	1.375 × 3.625	0.0210	7.3
16000	3186BE163U063AP	1.375 × 4.125	0.0182	8.3
19000	3186BF193U063AP	1.375 × 4.625	0.0163	9.2
21000	3186BG213U063AP	1.375 × 5.125	0.0150	10.0
24000	3186BH243U063AP	1.375 × 5.625	0.0139	10.8
12000	3186DA123U063AP	1.750 × 2.125	0.0528	4.3
14000	3186DB143U063AP	1.750 × 2.625	0.0448	5.1
19000	3186DC193U063AP	1.750 × 3.125	0.0346	6.2
24000	3186DD243U063AP	1.750 × 3.625	0.0286	7.2
29000	3186DE293U063AP	1.750 × 4.125	0.0247	8.2

63.0 VDC Working 85.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
34000	3186DF343U063AP	1.750 × 4.625	0.0219	9.1
39000	3186DG393U063AP	1.750 × 5.125	0.0199	10.0
43000	3186DH433U063AP	1.750 × 5.625	0.0183	10.8
15000	3186EA153U063AP	2.000 × 2.125	0.0204	7.6
18000	3186EB183U063AP	2.000 × 2.625	0.0174	8.9
25000	3186EC253U063AP	2.000 × 3.125	0.0136	10.7
31000	3186ED313U063AP	2.000 × 3.625	0.0114	12.4
37000	3186EE373U063AP	2.000 × 4.125	0.0099	13.9
44000	3186EF443U063AP	2.000 × 4.625	0.0089	15.4
50000	3186EG503U063AP	2.000 × 5.125	0.0082	16.8
56000	3186EH563U063AP	2.000 × 5.625	0.0076	18.1
27000	3186FB273U063AP	2.500 × 2.625	0.0231	8.9
37000	3186FC373U063AP	2.500× 3.125	0.0179	10.7
46000	3186FD463U063AP	2.500 × 3.625	0.0149	12.4
55000	3186FE553U063AP	2.500 × 4.125	0.0129	14.0
64000	3186FF643U063AP	2.500 × 4.625	0.0114	15.6
74000	3186FG743U063AP	2.500 × 5.125	0.0104	17.0
83000	3186FH833U063AP	2.500 × 5.625	0.0096	18.4
54000	3186GC543U063AP	3.000 × 3.125	0.0119	14.8
68000	3186GD683U063AP	3.000 × 3.625	0.0099	17.1
82000	3186GE823U063AP	3.000 × 4.125	0.0086	19.2
95000	3186GF953U063AP	3.000 × 4.625	0.0077	21.2
100000	3186GG104U063AP	3.000 × 5.125	0.0070	23.1
120000	3186GH124U063AP	3.000 × 5.625	0.0065	25.0
200000	3186GN204U063DP	3.000 × 8.625	0.0049	34.0

75.0 VDC Working 95.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
5300	3186BA532U075AP	1.375 × 2.125	0.0454	4.0
6400	3186BB642U075AP	1.375 × 2.625	0.0385	4.7
8500	3186BC852U075AP	1.375 × 3.125	0.0299	5.8
10000	3186BD103U075AP	1.375 × 3.625	0.0250	6.7
12000	3186BE123U075AP	1.375 × 4.125	0.0216	7.6
14000	3186BF143U075AP	1.375 × 4.625	0.0192	8.5
17000	3186BG173U075AP	1.375 × 5.125	0.0174	9.3
19000	3186BH193U075AP	1.375 × 5.625	0.0161	10.1
9400	3186DA942U075AP	1.750 × 2.125	0.0647	3.9
11000	3186DB113U075AP	1.750 × 2.625	0.0547	4.6
15000	3186DC153U075AP	1.750 × 3.125	0.0420	5.6
18000	3186DD183U075AP	1.750 × 3.625	0.0346	6.5
22000	3186DE223U075AP	1.750 × 4.125	0.0297	7.5
26000	3186DF263U075AP	1.750 × 4.625	0.0262	8.3
30000	3186DG303U075AP	1.750 × 5.125	0.0236	9.2
34000	3186DH343U075AP	1.750 × 5.625	0.0216	10.0
12000	3186EA123U075AP	2.000 × 2.125	0.0247	6.9
14000	3186EB143U075AP	2.000 × 2.625	0.0210	8.1
19000	3186EC193U075AP	2.000 × 3.125	0.0163	9.8
24000	3186ED243U075AP	2.000 × 3.625	0.0135	11.4
29000	3186EE293U075AP	2.000 × 4.125	0.0117	12.9
34000	3186EF343U075AP	2.000 × 4.625	0.0104	14.3
39000	3186EG393U075AP	2.000 × 5.125	0.0095	15.6
44000	3186EH443U075AP	2.000 × 5.625	0.0088	16.9

75.0 VDC Working 95.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
21000	3186FB213U075AP	2.500 × 2.625	0.0277	8.1
28000	3186FC283U075AP	2.500 × 3.125	0.0214	9.8
35000	3186FD353U075AP	2.500 × 3.625	0.0176	11.4
42000	3186FE423U075AP	2.500 × 4.125	0.0152	12.9
50000	3186FF503U075AP	2.500 × 4.625	0.0134	14.4
57000	3186FG573U075AP	2.500 × 5.125	0.0121	15.7
64000	3186FH643U075AP	2.500 × 5.625	0.0111	17.1
42000	3186GC423U075AP	3.000 × 3.125	0.0142	13.6
52000	3186GD523U075AP	3.000 × 3.625	0.0117	15.7
63000	3186GE633U075AP	3.000 × 4.125	0.0101	17.7
73000	3186GF733U075AP	3.000 × 4.625	0.0090	19.7
84000	3186GG843U075AP	3.000 × 5.125	0.0081	21.5
95000	3186GH953U075AP	3.000 × 5.625	0.0075	23.2
150000	3186GN154U075DP	3.000 × 8.625	0.0056	32.1

100.0 VDC Working 125.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
2700	3186BA272U100AP	1.375 × 2.125	0.0650	3.3
3300	3186BB332U100AP	1.375 × 2.625	0.0545	4.0
4400	3186BC442U100AP	1.375 × 3.125	0.0419	4.9
5500	3186BD552U100AP	1.375 × 3.625	0.0344	5.7
6600	3186BE662U100AP	1.375 × 4.125	0.0294	6.5
7700	3186BF772U100AP	1.375 × 4.625	0.0260	7.3
8800	31868G882U100AP	1.375 × 5.125	0.0234	8.0
9900	3186BH992U100AP	1.375 × 5.625	0.0214	8.7
4900	3186DA492U100AP	1.750 × 2.125	0.0709	3.7
5900	3186DB592U100AP	1.750 × 2.625	0.0598	4.4
7800	3186DC782U100AP	1.750 × 3.125	0.0460	5.4
9800	3186DD982U100AP	1.750 × 3.625	0.0377	6.3
11000	3186DE113U100AP	1.750 × 4.125	0.0325	7.1
13000	3186DF133U100AP	1.750 × 4.625	0.0285	8.0
15000	3186DG153U100AP	1.750 × 5.125	0.0257	8.8
17000	3186DH173U100AP	1.750 × 5.625	0.0234	9.6
6300	3186EA632U100AP	2.000 × 2.125	0.0809	3.8
7600	3186EB762U100AP	2.000 × 2.625	0.0682	4.5
10000	3186EC103U100AP	2.000 × 3.125	0.0523	5.5
12000	3186ED123U100AP	2.000 × 3.625	0.0430	6.4
15000	3186EE153U100AP	2.000 × 4.125	0.0366	7.3
17000	3186EF173U100AP	2.000 × 4.625	0.0323	8.1
20000	3186EG203U100AP	2.000 × 5.125	0.0119	13.9
22000	3186EH223U100AP	2.000 × 5.625	0.0110	15.1
12000	3186FB123U100AP	2.500 × 2.625	0.0314	7.6
17000	3186FC173U100AP	2.500 × 3.125	0.0240	9.3
21000	3186FD213U100AP	2.500 × 3.625	0.0198	10.8
25000	3186FE253U100AP	2.500 × 4.125	0.0170	12.2
29000	3186FF293U100AP	2.500 × 4.625	0.0150	13.6
34000	3186FG343U100AP	2.500 × 5.125	0.0135	14.9
38000	3186FH383U100AP	2.500 × 5.625	0.0123	16.2
25000	3186GC253U100AP	3.000 × 3.125	0.0160	12.8
31000	3186GD313U100AP	3.000 × 3.625	0.0132	14.8
37000	3186GE373U100AP	3.000 × 4.125	0.0113	16.7
44000	3186GF443U100AP	3.000 × 4.625	0.0100	18.6
50000	3186GG503U100AP	3.000 × 5.125	0.0090	20.4
56000	3186GH563U100AP	3.000 × 5.625	0.0083	22.1
94000	3186GN943U100DP	3.000 × 8.625	0.0060	30.8

150.0 VDC Working 175.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
1600	3186BA162T150AP	1.375 × 2.125	0.0732	3.2
1900	3186BB192T150AP	1.375 × 2.625	0.0618	3.7
2600	3186BC262T150AP	1.375 × 3.125	0.0470	4.6
3200	3186BD322T150AP	1.375 × 3.625	0.0387	5.4
3900	3186BE392T150AP	1.375 × 4.125	0.0329	6.2
4500	3186BF452T150AP	1.375 × 4.625	0.0290	6.9
5200	3186BG522T150AP	1.375 × 5.125	0.0259	7.6
5900	3186BH592T150AP	1.375 × 5.625	0.0236	8.3
2900	3186DA292T150AP	1.750 × 2.125	0.0755	3.6
3500	3186DB352T150AP	1.750 × 2.625	0.0635	4.3
4600	3186DC462T150AP	1.750 × 3.125	0.0488	5.2
5800	3186DD582T150AP	1.750 × 3.625	0.0400	6.1
7000	3186DE702T150AP	1.750 × 4.125	0.0341	7.0
8100	3186DF812T150AP	1.750 × 4.625	0.0300	7.8
9300	3186DG932T150AP	1.750 × 5.125	0.0135	12.1
10000	3186DH103T150AP	1.750 × 5.625	0.0125	13.1
3700	3186EA372T150AP	2.000 × 2.125	0.0846	3.7
4500	3186EB452T150AP	2.000 × 2.625	0.0711	4.4
6000	3186EC602T150AP	2.000 × 3.125	0.0545	5.3
7500	3186ED752T150AP	2.000 × 3.625	0.0446	6.3
9000	3186EE902T150AP	2.000 × 4.125	0.0164	10.8
10000	3186EF103T150AP	2.000 × 4.625	0.0147	12.0
12000	3186EG123T150AP	2.000 × 5.125	0.0130	13.3
13000	3186EH133T150AP	2.000 × 5.625	0.0120	14.4
7500	3186FB752T150AP	2.500 × 2.625	0.0330	7.4
10000	3186FC103T150AP	2.500 × 3.125	0.0254	9.0
12000	3186FD123T150AP	2.500 × 3.625	0.0209	10.5
15000	3186FE153T150AP	2.500 × 4.125	0.0178	11.9
17000	3186FF173T150AP	2.500 × 4.625	0.0158	13.3
20000	3186FG203T150AP	2.500 × 5.125	0.0141	14.6
22000	3186FH223T150AP	2.500 × 5.625	0.0130	15.8
14000	3186GC143T150AP	3.000 × 3.125	0.0311	9.2
18000	3186GD183T150AP	3.000 × 3.625	0.0254	10.7
22000	3186GE223T150AP	3.000 × 4.125	0.0216	12.1
26000	3186GF263T150AP	3.000 × 4.625	0.0189	13.5
29000	3186GG293T150AP	3.000 × 5.125	0.0170	14.8
33000	3186GH333T150AP	3.000 × 5.625	0.0155	16.1
55000	3186GN553T150AP	3.000 × 8.625	0.0109	22.9

200.0 VDC Working 250.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
1000	3186BA102T200AP	1.375 × 2.125	0.1086	2.6
1300	3186BB132T200AP	1.375 × 2.625	0.0875	3.1
1700	3186BC172T200AP	1.375 × 3.125	0.0672	3.8
2100	3186BD212T200AP	1.375 × 3.625	0.0550	4.5
2600	3186BE262T200AP	1.375 × 4.125	0.0459	5.2
3000	3186BF302T200AP	1.375 × 4.625	0.0403	5.8
3400	3186BG342T200AP	1.375 × 5.125	0.0360	6.5
3900	3186BH392T200AP	1.375 × 5.625	0.0324	7.1
1900	3186DA192T200AP	1.750 × 2.125	0.0929	3.3
2300	3186DB232T200AP	1.750 × 2.625	0.0780	3.8
3000	3186DC302T200AP	1.750 × 3.125	0.0599	4.7
3800	3186DD382T200AP	1.750 × 3.625	0.0487	5.5
4600	3186DE462T200AP	1.750 × 4.125	0.0413	6.3

200.0 VDC Working 250.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
5400	3186DF542T200AP	1.750 × 4.625	0.0214	9.2
6100	3186DG612T200AP	1.750 × 5.125	0.0192	10.2
6900	3186DH692T200AP	1.750 × 5.625	0.0173	11.1
2500	3186EA252T200AP	2.000 × 2.125	0.0977	3.5
3000	3186EB302T200AP	2.000 × 2.625	0.0821	4.1
4000	3186EC402T200AP	2.000 × 3.125	0.0628	5.0
5000	3186ED502T200AP	2.000 × 3.625	0.0258	8.2
6000	3186EE602T200AP	2.000 × 4.125	0.0219	9.4
7000	3186EF702T200AP	2.000 × 4.625	0.0192	10.5
8000	3186EG802T200AP	2.000 × 5.125	0.0172	11.6
9000	3186EH902T200AP	2.000 × 5.625	0.0156	12.6
5000	3186FB502T200AP	2.500 × 2.625	0.0396	6.8
6700	3186FC672T200AP	2.500 × 3.125	0.0303	8.3
8300	3186FD832T200AP	2.500 × 3.625	0.0248	9.6
10000	3186FE103T200AP	2.500 × 4.125	0.0211	11.0
11000	3186FF113T200AP	2.500 × 4.625	0.0187	12.2
13000	3186FG133T200AP	2.500 × 5.125	0.0167	13.4
15000	3186FH153T200AP	2.500 × 5.625	0.0151	14.6
9800	3186GC982T200AP	3.000 × 3.125	0.0343	8.7
12000	3186GD123T200AP	3.000 × 3.625	0.0281	10.2
14000	3186GE143T200AP	3.000 × 4.125	0.0240	11.5
17000	3186GF173T200AP	3.000 × 4.625	0.0209	12.9
19000	3186GG193T200AP	3.000 × 5.125	0.0188	14.1
22000	3186GH223T200AP	3.000 × 5.625	0.0170	15.4
37000	3186GN373T200AP	3.000 × 8.625	0.0118	22.0

250.0 VDC Working 300.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
790	3186BA791T250AP	1.375 × 2.125	0.1158	2.5
940	3186BB941T250AP	1.375 × 2.625	0.0976	3.0
1200	3186BC122T250AP	1.375 × 3.125	0.0760	3.6
1500	3186BD152T250AP	1.375 × 3.625	0.0617	4.3
1800	3186BE182T250AP	1.375 × 4.125	0.0522	4.9
2200	3186BF222T250AP	1.375 × 4.625	0.0443	5.6
2500	3186BG252T250AP	1.375 × 5.125	0.0396	6.2
2800	3186BH282T250AP	1.375 × 5.625	0.0359	6.8
1400	3186DA142T250AP	1.750 × 2.125	0.0994	3.2
1600	3186DB162T250AP	1.750 × 2.625	0.0848	3.7
2200	3186DC222T250AP	1.750 × 3.125	0.0641	4.5
2800	3186DD282T250AP	1.750 × 3.625	0.0519	5.3
3300	3186DE332T250AP	1.750 × 4.125	0.0276	7.7
3900	3186DF392T250AP	1.750 × 4.625	0.0239	8.7
4500	3186DG452T250AP	1.750 × 5.125	0.0211	9.7
5000	3186DH502T250AP	1.750 × 5.625	0.0192	10.6
1800	3186EA182T250AP	2.000 × 2.125	0.1031	3.4
2100	3186EB212T250AP	2.000 × 2.625	0.0872	4.0
2900	3186EC292T250AP	2.000 × 3.125	0.0661	4.9
3600	3186ED362T250AP	2.000 × 3.625	0.0285	7.3
4300	3186EE432T250AP	2.000 × 4.125	0.0242	8.9
5100	3186EF512T250AP	2.000 × 4.625	0.0210	10.0
5800	3186EG582T250AP	2.000 × 5.125	0.0188	11.1
6500	3186EH652T250AP	2.000 × 5.625	0.0171	12.1
3600	3186FB362T250AP	2.500 × 2.625	0.0423	6.6
4800	3186FC482T250AP	2.500 × 3.125	0.0324	8.0

250.0 VDC Working 300.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
6000	3186FD602T250AP	2.500 × 3.625	0.0264	9.3
7300	3186FE732T250AP	2.500 × 4.125	0.0224	10.6
8500	3186FF852T250AP	2.500 × 4.625	0.0196	11.9
9700	3186FG972T250AP	2.500 × 5.125	0.0176	13.1
10000	3186FH103T250AP	2.500 × 5.625	0.0163	14.1
7100	3186GC712T250AP	3.000 × 3.125	0.0357	8.6
8900	3186GD892T250AP	3.000 × 3.625	0.0291	10.0
10000	3186GE103T250AP	3.000 × 4.125	0.0250	11.3
12000	3186GF123T250AP	3.000 × 4.625	0.0218	12.6
14000	3186GG143T250AP	3.000 × 5.125	0.0194	13.9
16000	3186GH163T250AP	3.000 × 5.625	0.0176	15.1
26000	3186GN263T250AP	3.000 × 8.625	0.0122	21.7

300.0 VDC Working 350.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
520	3186BA521T300AP	1.375 × 2.125	0.1197	2.5
630	3186BB631T300AP	1.375 × 2.625	0.0999	2.9
840	3186BC841T300AP	1.375 × 3.125	0.0759	3.6
1000	3186BD102T300AP	1.375 × 3.625	0.0633	4.2
1200	3186BE122T300AP	1.375 × 4.125	0.0535	4.8
1400	3186BF142T300AP	1.375 × 4.625	0.0466	5.4
1600	3186BG162T300AP	1.375 × 5.125	0.0414	6.0
1800	3186BH182T300AP	1.375 × 5.625	0.0374	6.6
930	3186DA931T300AP	1.750 × 2.125	0.1013	3.1
1100	3186DB112T300AP	1.750 × 2.625	0.0855	3.7
1400	3186DC142T300AP	1.750 × 3.125	0.0662	4.5
1800	3186DD182T300AP	1.750 × 3.625	0.0534	5.3
2200	3186DE222T300AP	1.750 × 4.125	0.0451	6.0
2600	3186DF262T300AP	1.750 × 4.625	0.0245	8.6
2900	3186DG292T300AP	1.750 × 5.125	0.0221	9.5
3300	3186DH332T300AP	1.750 × 5.625	0.0198	10.4
1200	3186EA122T300AP	2.000 × 2.125	0.1045	3.4
1400	3186EB142T300AP	2.000 × 2.625	0.0885	3.9
1900	3186EC192T300AP	2.000 × 3.125	0.0672	4.8
2400	3186ED242T300AP	2.000 × 3.625	0.0292	7.7
2900	3186EE292T300AP	2.000 × 4.125	0.0247	8.8
3300	3186EF332T300AP	2.000 × 4.625	0.0218	9.9
3800	3186EG382T300AP	2.000 × 5.125	0.0194	10.9
4300	3186EH432T300AP	2.000 × 5.625	0.0175	11.9
2400	3186FB242T300AP	2.500 × 2.625	0.0430	6.5
3200	3186FC322T300AP	2.500 × 3.125	0.0329	7.9
4000	3186FD402T300AP	2.500 × 3.625	0.0268	9.3
4800	3186FE482T300AP	2.500 × 4.125	0.0228	10.5
5600	3186FF562T300AP	2.500 × 4.625	0.0200	11.8
6400	3186FG642T300AP	2.500 × 5.125	0.0179	13.0
7300	3186FH732T300AP	2.500 × 5.625	0.0162	14.1
4700	3186GC472T300AP	3.000 × 3.125	0.0361	8.5
5900	3186GD592T300AP	3.000 × 3.625	0.0294	9.9
7100	3186GE712T300AP	3.000 × 4.125	0.0250	11.3
8300	3186GF832T300AP	3.000 × 4.625	0.0219	12.6
9500	3186GG952T300AP	3.000 × 5.125	0.0196	13.8
10000	3186GH103T300AP	3.000 × 5.625	0.0180	15.0
14000	3186GN143T300AP	3.000 × 8.625	0.0143	20.0

 Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

350.0 VDC Working 400.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
430	3186BA431T350AP	1.375 × 2.125	0.2548	1.7
510	3186BB511T350AP	1.375 × 2.625	0.2149	2.0
680	3186BC681T350AP	1.375 × 3.125	0.1622	2.5
860	3186BD861T350AP	1.375 × 3.625	0.1295	2.9
1000	3186BE102T350AP	1.375 × 4.125	0.1114	3.3
1200	3186BF122T350AP	1.375 × 4.625	0.0941	3.8
1300	3186BG132T350AP	1.375 × 5.125	0.0865	4.2
1500	3186BH152T350AP	1.375 × 5.625	0.0760	4.6
760	3186DA761T350AP	1.750 × 2.125	0.1755	2.4
920	3186DB921T350AP	1.750 × 2.625	0.1464	2.8
1200	3186DC122T350AP	1.750 × 3.125	0.1120	3.4
1500	3186DD152T350AP	1.750 × 3.625	0.0906	4.0
1800	3186DE182T350AP	1.750 × 4.125	0.0608	5.2
2100	3186DF212T350AP	1.750 × 4.625	0.0525	5.9
2400	3186DG242T350AP	1.750 × 5.125	0.0463	6.5
2700	3186DH272T350AP	1.750 × 5.625	0.0414	7.2
990	3186EA991T350AP	2.000 × 2.125	0.1607	2.7
1100	3186E8112T350AP	2.000 × 2.625	0.1383	3.1
1500	3186EC152T350AP	2.000 × 3.125	0.1041	3.9
1900	3186ED192T350AP	2.000 × 3.625	0.0603	5.4
2300	3186EE232T350AP	2.000 × 4.125	0.0504	6.2
2700	3186EF272T350AP	2.000 × 4.625	0.0434	7.0
3100	3186EG312T350AP	2.000 × 5.125	0.0382	7.8
3500	3186EH352T350AP	2.000 × 5.625	0.0342	8.5
1600	3186FB162T350AP	2.500 × 2.625	0.1411	3.6
2100	3186FC212T350AP	2.500 × 3.125	0.0658	5.6
2700	3186FD272T350AP	2.500 × 3.625	0.0531	6.6
3200	3186FE322T350AP	2.500 × 4.125	0.0450	7.5
3800	3186FF382T350AP	2.500 × 4.625	0.0386	8.5
4300	3186FG432T350AP	2.500 × 5.125	0.0344	9.3
4900	3186FH492T350AP	2.500 × 5.625	0.0307	10.3
3200	3186GC322T350AP	3.000 × 3.125	0.0551	6.9
4000	3186GD402T350AP	3.000 × 3.625	0.0447	8.1
4800	3186GE482T350AP	3.000 × 4.125	0.0377	9.2
5600	3186GF562T350AP	3.000 × 4.625	0.0328	10.3
6400	3186GG642T350AP	3.000 × 5.125	0.0291	11.3
7300	3186GH732T350AP	3.000 × 5.625	0.0261	12.4
12000	3186GN123T350AP	3.000 × 8.625	0.0173	18.2

400.0 VDC Working 450.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
350	3186BA351T400AP	1.375 × 2.125	0.2781	1.6
420	3186BB421T400AP	1.375 × 2.625	0.2324	1.9
570	3186BC571T400AP	1.375 × 3.125	0.1728	2.4
710	3186BD711T400AP	1.375 × 3.625	0.1395	2.8
850	3186BE851T400AP	1.375 × 4.125	0.1172	3.3
900	3186BF901T400AP	1.375 × 4.625	0.1097	3.5
1100	3186BG112T400AP	1.375 × 5.125	0.0914	4.1
1200	3186BH122T400AP	1.375 × 5.625	0.0840	4.4
630	3186DA631T400AP	1.750 × 2.125	0.1815	2.3
760	3186DB761T400AP	1.750 × 2.625	0.1515	2.8
1000	3186DC102T400AP	1.750 × 3.125	0.1156	3.4
1200	3186DD122T400AP	1.750 × 3.625	0.0956	3.9

400.0 VDC Working 450.0 Surge *(continued)*

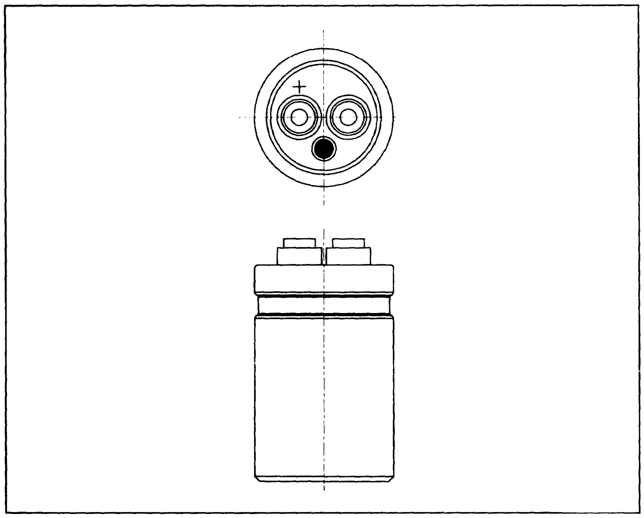
Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
1500	3186DE152T400AP	1.750 × 4.125	0.0653	5.0
1700	3186DF172T400AP	1.750 × 4.625	0.0577	5.6
2000	3186DG202T400AP	1.750 × 5.125	0.0496	6.3
2200	3186DH222T400AP	1.750 × 5.625	0.0453	6.9
820	3186EA821T400AP	2.000 × 2.125	0.1616	2.7
980	3186EB981T400AP	2.000 × 2.625	0.1356	3.2
1300	3186EC132T400AP	2.000 × 3.125	0.0780	4.5
1600	3186ED162T400AP	2.000 × 3.625	0.0636	5.2
1900	3186EE192T400AP	2.000 × 4.125	0.0539	6.0
2300	3186EF232T400AP	2.000 × 4.625	0.0453	6.8
2600	3186EG262T400AP	2.000 × 5.125	0.0404	7.6
2900	3186EH292T400AP	2.000 × 5.625	0.0365	8.3
1300	3186FB132T400AP	2.500 × 2.625	0.0939	4.4
1800	3186FC182T400AP	2.500 × 3.125	0.0692	5.5
2200	3186FD222T400AP	2.500 × 3.625	0.0568	6.4
2700	3186FE272T400AP	2.500 × 4.125	0.0471	7.3
3100	3186FF312T400AP	2.500 × 4.625	0.0412	8.2
3600	3186FG362T400AP	2.500 × 5.125	0.0361	9.1
4000	3186FH402T400AP	2.500 × 5.625	0.0327	10.0
2600	3186GC262T400AP	3.000 × 3.125	0.0564	6.8
3300	3186GD332T400AP	3.000 × 3.625	0.0454	8.0
4000	3186GE402T400AP	3.000 × 4.125	0.0382	9.1
4700	3186GF472T400AP	3.000 × 4.625	0.0331	10.2
5300	3186GG532T400AP	3.000 × 5.125	0.0295	11.3
6000	3186GH602T400AP	3.000 × 5.625	0.0265	12.3
10000	3186GN103T400AP	3.000 × 8.625	0.0175	18.1

450.0 VDC Working 525.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
250	3186BA251T450AP	1.375 × 2.125	0.3946	1.4
300	3186BB301T450AP	1.375 × 2.625	0.3295	1.6
410	3186BC411T450AP	1.375 × 3.125	0.2427	2.0
510	3186BD511T450AP	1.375 × 3.625	0.1959	2.4
610	3186BE611T450AP	1.375 × 4.125	0.1645	2.8
710	3186BF711T450AP	1.375 × 4.625	0.1420	3.1
820	3186BG821T450AP	1.375 × 5.125	0.1238	3.5
920	3186BH921T450AP	1.375 × 5.625	0.1109	3.8
460	3186DA461T450AP	1.750 × 2.125	0.2376	2.0
550	3186DB551T450AP	1.750 × 2.625	0.1992	2.4
730	3186DC731T450AP	1.750 × 3.125	0.1510	3.0
920	3186DD921T450AP	1.750 × 3.625	0.1210	3.5
1100	3186DE112T450AP	1.750 × 4.125	0.0904	4.3
1200	3186DF122T450AP	1.750 × 4.625	0.0828	4.7
1400	3186DG142T450AP	1.750 × 5.125	0.0714	5.3
1600	3186DH162T450AP	1.750 × 5.625	0.0629	5.8
590	3186EA591T450AP	2.000 × 2.125	0.2016	2.4
710	3186EB711T450AP	2.000 × 2.625	0.1685	2.8
950	3186EC951T450AP	2.000 × 3.125	0.1272	3.5
1100	3186ED112T450AP	2.000 × 3.625	0.0919	4.4
1400	3186EE142T450AP	2.000 × 4.125	0.0732	5.1
1600	3186EF162T450AP	2.000 × 4.625	0.0643	5.7
1900	3186EG192T450AP	2.000 × 5.125	0.0548	6.5
2100	3186EH212T450AP	2.000 × 5.625	0.0498	7.1
1200	3186FB122T450AP	2.500 × 2.625	0.0940	4.4

450.0 VDC Working 525.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
1600	3186FC162T450AP	2.500 × 3.125	0.0711	5.4
2000	3186FD202T450AP	2.500 × 3.625	0.0574	6.3
2400	3186FE242T450AP	2.500 × 4.125	0.0483	7.2
2800	3186FF282T450AP	2.500 × 4.625	0.0418	8.1
3200	3186FG322T450AP	2.500 × 5.125	0.0370	9.0
3600	3186FH362T450AP	2.500 × 5.625	0.0332	9.9
2300	3186GC232T450AP	3.000 × 3.125	0.0579	6.7
2900	3186GD292T450AP	3.000 × 3.625	0.0467	7.9
3500	3186GE352T450AP	3.000 × 4.125	0.0393	9.0
4100	3186GF412T450AP	3.000 × 4.625	0.0341	10.1
4700	3186GG472T450AP	3.000 × 5.125	0.0302	11.1
5300	3186GH532T450AP	3.000 × 5.625	0.0272	12.2
8800	3186GN882T450AP	3.000 × 8.625	0.0179	17.9



Long-Life Computer-Grade Aluminum Electrolytic Capacitors

Description

Series 3188 Long-Life Aluminum Electrolytic Capacitors are designed for those applications where a standard computer-grade product must operate under enviromental and operational stresses more severe than those normally encountered. These units are constructed of the highest-quality materials and processed to achieve the low leakage current necessary for long shelf life and long operating life with high ripple currents. The Series 3188 features a 2000 hour operating life at 105°C.

Features

- 4000 hours operating life at 85°C.
- Up to 45A Ripple Current at 85°C.
- 39 Standard Case Sizes.
- Low Leakage Current.
- Computer-designed for optimum performance.
- Meets all requirements for EIA-RS-395 for type I capacitors.
- Voltage range: 6 to 400 WVDC.
- Operating Temperature: −40°C – +105°C.
- Termination: Screw terminals.

Performance Characteristics: See page 95
Life Prediction Guidelines: See page 99
Application Guidelines: See page 105

How to Specify

Philips Components Series Capacitors can be completely specified using the following designation:

XXXX BA 942 U 005 A M A-1

- **XXXX** — Philips Components Product Series
- **BA** — Case Size Code
- **942** — Capacitance: XX = Significant Digits, X = Multiplier, i.e. 942 = 9400μF
- **U** — Tolerance: U = −10%+75%, T = −10%+50%
- **005** — Voltage: 005 = 5VDC, 050 = 50VDC
- **A** — Terminal Style: A = High Post, B = Low Post, D = High Current, H = PC Mount
- **M** — Insulation & Bracket Code (see physical spec)
- **A-1** — Factory Assigned Number

Physical Specifications Computer Grade

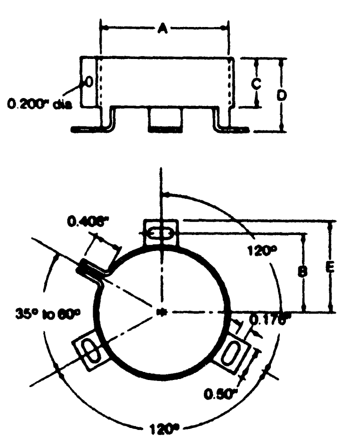
Insulated Case Dimension Adder And Bracket Codes								
	Inches			MM			Bracket	
Insulation Type	D	L	H	D	L	H	without	with
.004 inch Polymeric	.010	.015	.010	.25	.38	.25	M	L
.008 inch Polymeric	.020	.032	.024	.508	.813	.61	P	R
.012 inch Polymeric	.025	.062	.045	.63	1.58	1.14	H	J
Uninsulated	—	—	—	—	—	—	N	X

Bracket Dimensions

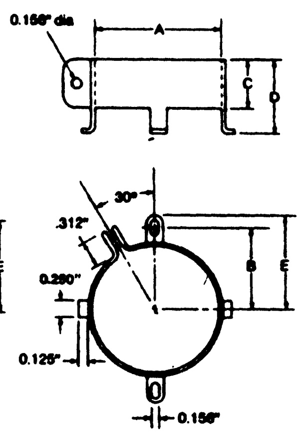
Case Diameters	Dimensions in Inches				
	A ±0.005	B ±0.031	C ±0.016	D ±0.031	E ±0.031
1.375	1.375	0.906	0.562	0.750	1.156
1.750	1.750	1.125	0.750	1.125	1.313
2.000	2.000	1.250	0.750	1.125	1.438
2.500	2.500	1.500	0.750	1.125	1.688
3.000	3.000	1.750	0.750	1.125	1.938

Case Diameters	Dimensions in Millimeters				
	A ±0.13	B ±0.79	C ±0.40	D ±0.79	E ±0.79
34.92	34.92	23.01	14.25	19.05	29.36
44.45	44.45	28.57	19.05	28.57	33.35
50.80	50.80	31.75	19.05	28.57	36.51
63.50	63.50	38.10	19.05	28.57	42.87
76.20	76.20	44.45	19.05	28.57	49.22

Bracket Outline Drawing



For 1-3/4(D), 2(E), 2-1/2(F), and 3(G) inch diameter can sizes



For 1-3/8(B) inch diameter can sizes

Physical Specifications Computer Grade

Dimensions

Case Code*	Uninsulated Case Dimensions					
	Dimensions in Inches			Dimensions in Millimeters		
	D	L	S	D	L	S
BA	1.375	2.125	.500	34.92	53.97	12.70
BB	1.375	2.625	.500	34.92	66.67	12.70
BC	1.375	3.125	.500	34.92	79.37	12.70
BD	1.375	3.625	.500	34.92	92.07	12.70
BE	1.375	4.125	.500	34.92	104.77	12.70
BF	1.375	4.625	.500	34.92	117.47	12.70
BG	1.375	5.125	.500	34.92	130.17	12.70
BH	1.375	5.625	.500	34.92	142.87	12.70
DA	1.750	2.125	.750	44.45	53.97	19.05
DB	1.750	2.625	.750	44.45	66.67	19.05
DC	1.750	3.125	.750	44.45	79.37	19.05
DD	1.750	3.625	.750	44.45	92.07	19.05
DE	1.750	4.125	.750	44.45	104.77	19.05
DF	1.750	4.625	.750	44.45	117.47	19.05
DG	1.750	5.125	.750	44.45	130.17	19.05
DH	1.750	5.625	.750	44.45	142.87	19.05
EA	2.000	2.125	.875	50.80	53.97	22.22
EB	2.000	2.625	.875	50.80	66.67	22.22
EC	2.000	3.125	.875	50.80	79.37	22.22
ED	2.000	3.625	.875	50.80	92.07	22.22
EE	2.000	4.125	.875	50.80	104.77	22.22
EF	2.000	4.625	.875	50.80	117.47	22.22
EG	2.000	5.125	.875	50.80	130.17	22.22
EH	2.000	5.625	.875	50.80	142.87	22.22
FB	2.500	2.625	1.125	63.50	66.67	28.57
FC	2.500	3.125	1.125	63.50	79.37	28.57
FD	2.500	3.625	1.125	63.50	92.07	28.57
FE	2.500	4.125	1.125	63.50	104.77	28.57
FF	2.500	4.625	1.125	63.50	117.47	28.57
FG	2.500	5.125	1.125	63.50	130.17	28.57
FH	2.500	5.625	1.125	63.50	142.87	28.57
GC	3.000	3.125	1.250	76.20	79.37	31.75
GD	3.000	3.625	1.250	76.20	92.07	31.75
GE	3.000	4.125	1.250	76.20	104.77	31.75
GF	3.000	4.625	1.250	76.20	117.47	31.75
GG	3.000	5.125	1.250	76.20	130.17	31.75
GH	3.000	5.625	1.250	76.20	142.87	31.75
GJ	3.000	5.875	1.250	76.20	149.22	31.75
GN	3.000	8.625	1.250	76.20	219.07	31.75

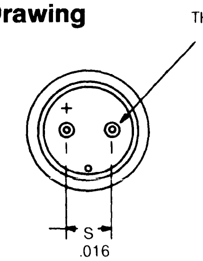
PC Mount Overall Height (Inches)

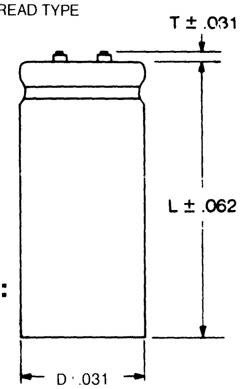
Case Length	H
2.125	2.31
2.625	2.81
3.125	3.31
3.625	3.81
4.125	4.31
4.625	4.81
5.125	5.31
5.625	5.81

PC Mount Terminal Spacing (Inches)

Case Diameter	X	Y	Z
1.375	.550	.500	.375
1.750	.900	.700	.525
2.000	1.000	.800	.575

Case Outline Drawing



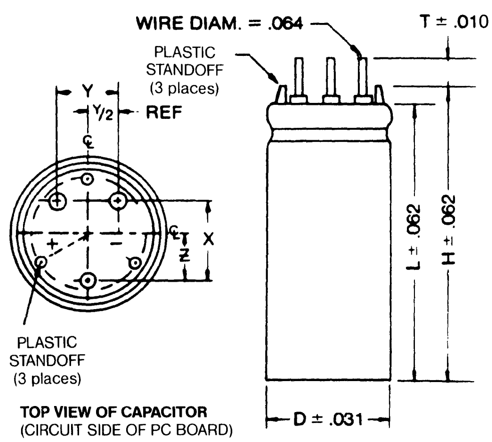


The capacitors are marked with:

- nominal capacitance
- rated voltage
- EIA source and date code
- maximum ambient temperature
- polarity
- name of manufacturer
- part number
- capacitance tolerance

Case Outline Drawing

PRINTED CIRCUIT BOARD MOUNT



Terminal Styles, Dimensions, and Code				
Terminal Style	T (inches)	T (mm)	Code	Thread Type
High Post	.250	6.4	A	10-32
Low Post	.063	1.6	B	10-32
High Current*	.093	3.2	D	¼-28
PC Mount**	.250	6.4	H	N/A

*Available in 2½" and 3" diameter cans only. Recommended for applications where ripple current exceeds 30 Amperes.
**Contact factory for maximum capacitance.
EA can only multiply .8 time capacitance table.

5.0 VDC Working 7.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
57000	3188BA573U005AP	1.375 × 2.125	0.0129	10.6
68000	3188BB683U005AP	1.375 × 2.625	0.0111	12.4
91000	3188BC913U005AP	1.375 × 3.125	0.0088	15.0
110000	3188BD114U005AP	1.375 × 3.625	0.0076	17.2
130000	3188BE134U005AP	1.375 × 4.125	0.0067	19.3
160000	3188BF164U005AP	1.375 × 4.625	0.0060	21.4
180000	3188BG184U005AP	1.375 × 5.125	0.0056	23.1
200000	3188BH204U005AP	1.375 × 5.625	0.0053	24.8
100000	3188DA104U005AP	1.750 × 2.125	0.0084	15.4
120000	3188DB124U005AP	1.750 × 2.625	0.0072	17.9
160000	3188DC164U005AP	1.750 × 3.125	0.0058	21.4
200000	3188DD204U005AP	1.750 × 3.625	0.0049	24.5
240000	3188DE244U005AP	1.750 × 4.125	0.0044	27.4
280000	3188DF284U005AP	1.750 × 4.625	0.0040	30.0
320000	3188DG324U005AP	1.750 × 5.125	0.0038	30.0
360000	3188DH364U005AP	1.750 × 5.625	0.0036	30.0
130000	3188EA134U005AP	2.000 × 2.125	0.0064	19.2
150000	3188EB154U005AP	2.000 × 2.625	0.0056	22.2
210000	3188EC214U005AP	2.000 × 3.125	0.0044	26.5
260000	3188ED264U005AP	2.000 × 3.625	0.0038	30.0
310000	3188EE314U005AP	2.000 × 4.125	0.0034	30.0
370000	3188EF374U005AP	2.000 × 4.625	0.0031	30.0
420000	3188EG424U005AP	2.000 × 5.125	0.0029	30.0
470000	3188EH474U005AP	2.000 × 5.625	0.0028	30.0
260000	3188FB264U005DP	2.500 × 2.625	0.0037	31.4
350000	3188FC354U005DP	2.500× 3.125	0.0030	37.1
440000	3188FD444U005DP	2.500 × 3.625	0.0026	42.3
530000	3188FE534U005DP	2.500 × 4.125	0.0023	45.0
610000	3188FF614U005DP	2.500 × 4.625	0.0021	45.0
700000	3188FG704U005DP	2.500 × 5.125	0.0020	45.0
790000	3188FH794U005DP	2.500 × 5.625	0.0019	45.0
520000	3188GC524U005DP	3.000 × 3.125	0.0023	45.0
650000	3188GD654U005DP	3.000 × 3.625	0.0020	45.0
780000	3188GE784U005DP	3.000 × 4.125	0.0018	45.0
910000	3188GF914U005DP	3.000 × 4.625	0.0016	45.0
1000000	3188GG105U005DP	3.000 × 5.125	0.0015	45.0
1100000	3188GH115U005DP	3.000 × 5.625	0.0015	45.0
1900000	3188GN195U005DP	3.000 × 8.625	0.0013	45.0

7.5 VDC Working 10.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
45000	3188BA453U7P5AP	1.375 × 2.125	0.0131	10.5
54000	3188BB543U7P5AP	1.375 × 2.625	0.0113	12.4
72000	3188BC723U7P5AP	1.375 × 3.125	0.0089	14.9
91000	3188BD913U7P5AP	1.375 × 3.625	0.0076	17.2
100000	3188BE104U7P5AP	1.375 × 4.125	0.0069	19.1
120000	3188BF124U7P5AP	1.375 × 4.625	0.0062	21.1
140000	3188BG144U7P5AP	1.375 × 5.125	0.0057	23.0
160000	3188BH164U7P5AP	1.375 × 5.625	0.0054	24.7
81000	3188DA813U7P5AP	1.750 × 2.125	0.0085	15.3
97000	3188DB973U7P5AP	1.750 × 2.625	0.0073	17.8
120000	3188DC124U7P5AP	1.750 × 3.125	0.0059	21.1
160000	3188DD164U7P5AP	1.750 × 3.625	0.0050	24.4

7.5 VDC Working 10.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
190000	3188DE194U7P5AP	1.750 × 4.125	0.0044	27.3
220000	3188DF224U7P5AP	1.750 × 4.625	0.0041	29.9
250000	3188DG254U7P5AP	1.750 × 5.125	0.0038	30.0
290000	3188DH294U7P5AP	1.750 × 5.625	0.0036	30.0
100000	3188EA104U7P5AP	2.000 × 2.125	0.0088	16.4
120000	3188EB124U7P5AP	2.000 × 2.625	0.0076	19.0
160000	3188EC164U7P5AP	2.000 × 3.125	0.0061	22.6
210000	3188ED214U7P5AP	2.000 × 3.625	0.0052	26.0
250000	3188EE254U7P5AP	2.000 × 4.125	0.0046	29.0
290000	3188EF294U7P5AP	2.000 × 4.625	0.0042	30.0
330000	3188EG334U7P5AP	2.000 × 5.125	0.0039	30.0
370000	3188EH374U7P5AP	2.000 × 5.625	0.0037	30.0
210000	3188FB214U7P5AP	2.500 × 2.625	0.0046	28.2
280000	3188FC284U7P5DP	2.500 × 3.125	0.0037	33.4
350000	3188FD354U7P5DP	2.500 × 3.625	0.0032	38.1
420000	3188FE424U7P5DP	2.500 × 4.125	0.0028	42.3
490000	3188FF494U7P5DP	2.500 × 4.625	0.0026	45.0
560000	3188FG564U7P5DP	2.500 × 5.125	0.0024	45.0
630000	3188FH634U7P5DP	2.500 × 5.625	0.0023	45.0
410000	3188GC414U7P5DP	3.000 × 3.125	0.0027	43.9
510000	3188GD514U7P5DP	3.000 × 3.625	0.0023	45.0
620000	3188GE624U7P5DP	3.000 × 4.125	0.0021	45.0
720000	3188GF724U7P5DP	3.000 × 4.625	0.0019	45.0
820000	3188GG824U7P5DP	3.000 × 5.125	0.0018	45.0
930000	3188GH934U7P5DP	3.000 × 5.625	0.0017	45.0
1500000	3188GN155U7P5DP	3.000 × 8.625	0.0015	45.0

10.0 VDC Working 15.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
38000	3188BA383U010AP	1.375 × 2.125	0.0132	10.5
46000	3188BB463U010AP	1.375 × 2.625	0.0113	12.3
61000	3188BC613U010AP	1.375 × 3.125	0.0090	14.8
76000	3188BD763U010AP	1.375 × 3.625	0.0077	17.1
92000	3188BE923U010AP	1.375 × 4.125	0.0068	19.2
100000	3188BF104U010AP	1.375 × 4.625	0.0063	21.0
120000	3188BG124U010AP	1.375 × 5.125	0.0057	22.9
130000	3188BH134U010AP	1.375 × 5.625	0.0055	24.5
68000	3188DA683U010AP	1.750 × 2.125	0.0136	12.1
81000	3188DB813U010AP	1.750 × 2.625	0.0117	14.1
100000	3188DC104U010AP	1.750 × 3.125	0.0093	16.8
130000	3188DD134U010AP	1.750 × 3.625	0.0079	19.4
160000	3188DE164U010AP	1.750 × 4.125	0.0070	21.7
190000	3188DF194U010AP	1.750 × 4.625	0.0064	23.9
210000	3188DG214U010AP	1.750 × 5.125	0.0059	25.8
240000	3188DH244U010AP	1.750 × 5.625	0.0056	27.7
88000	3188EA883U010AP	2.000 × 2.125	0.0088	16.3
100000	3188EB104U010AP	2.000 × 2.625	0.0076	18.9
140000	3188EC144U010AP	2.000 × 3.125	0.0061	22.6
170000	3188ED174U010AP	2.000 × 3.625	0.0052	25.9
210000	3188EE214U010AP	2.000 × 4.125	0.0046	28.9
240000	3188EF244U010AP	2.000 × 4.625	0.0042	30.0
280000	3188EG284U010AP	2.000 × 5.125	0.0040	30.0
310000	3188EH314U010AP	2.000 × 5.625	0.0038	30.0
170000	3188FB174U010AP	2.500 × 2.625	0.0046	28.1

Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

10.0 VDC Working 15.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
230000	3188FC234U010DP	2.500 × 3.125	0.0037	33.3
290000	3188FD294U010DP	2.500 × 3.625	0.0032	38.0
350000	3188FE354U010DP	2.500 × 4.125	0.0028	42.2
410000	3188FF414U010DP	2.500 × 4.625	0.0026	45.0
470000	3188FG474U010DP	2.500 × 5.125	0.0024	45.0
530000	3188FH534U010DP	2.500 × 5.625	0.0023	45.0
340000	3188GC344U010DP	3.000 × 3.125	0.0027	43.8
430000	3188GD434U010DP	3.000 × 3.625	0.0023	45.0
520000	3188GE524U010DP	3.000 × 4.125	0.0021	45.0
610000	3188GF614U010DP	3.000 × 4.625	0.0019	45.0
690000	3188GG694U010DP	3.000 × 5.125	0.0018	45.0
780000	3188GH784U010DP	3.000 × 5.625	0.0017	45.0
1300000	3188GN135U010DP	3.000 × 8.625	0.0015	45.0

15.0 VDC Working 20.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
28000	3188BA283U015AP	1.375 × 2.125	0.0146	10.0
33000	3188BB333U015AP	1.375 × 2.625	0.0125	11.7
45000	3188BC453U015AP	1.375 × 3.125	0.0099	14.1
56000	3188BD563U015AP	1.375 × 3.625	0.0083	16.4
67000	3188BE673U015AP	1.375 × 4.125	0.0073	18.4
79000	3188BF793U015AP	1.375 × 4.625	0.0066	20.4
90000	3188BG903U015AP	1.375 × 5.125	0.0061	22.1
100000	3188BH104U015AP	1.375 × 5.625	0.0058	23.8
50000	3188DA503U015AP	1.750 × 2.125	0.0165	11.0
60000	3188DB603U015AP	1.750 × 2.625	0.0141	12.8
80000	3188DC803U015AP	1.750 × 3.125	0.0111	15.4
100000	3188DD104U015AP	1.750 × 3.625	0.0094	17.8
120000	3188DE124U015AP	1.750 × 4.125	0.0082	20.0
140000	3188DF144U015AP	1.750 × 4.625	0.0074	22.1
160000	3188DG164U015AP	1.750 × 5.125	0.0068	24.1
180000	3188DH184U015AP	1.750 × 5.625	0.0064	25.9
65000	3188EA653U015AP	2.000 × 2.125	0.0105	15.0
78000	3188EB783U015AP	2.000 × 2.625	0.0090	17.4
100000	3188EC104U015AP	2.000 × 3.125	0.0072	20.8
130000	3188ED134U015AP	2.000 × 3.625	0.0061	24.0
150000	3188EE154U015AP	2.000 × 4.125	0.0054	26.9
180000	3188EF184U015AP	2.000 × 4.625	0.0048	29.6
200000	3188EG204U015AP	2.000 × 5.125	0.0045	30.0
230000	3188EH234U015AP	2.000 × 5.625	0.0042	30.0
130000	3188FB134U015AP	2.500 × 2.625	0.0055	25.8
170000	3188FC174U015DP	2.500× 3.125	0.0044	30.8
210000	3188FD214U015DP	2.500 × 3.625	0.0037	35.2
260000	3188FE264U015DP	2.500 × 4.125	0.0033	39.4
300000	3188FF304U015DP	2.500 × 4.625	0.0030	43.2
340000	3188FG344U015DP	2.500 × 5.125	0.0028	45.0
390000	3188FH394U015DP	2.500 × 5.625	0.0026	45.0
250000	3188GC254U015DP	3.000 × 3.125	0.0032	40.4
320000	3188GD324U015DP	3.000 × 3.625	0.0027	45.0
380000	3188GE384U015DP	3.000 × 4.125	0.0024	45.0
440000	3188GF444U015DP	3.000 × 4.625	0.0022	45.0
510000	3188GG514U015DP	3.000 × 5.125	0.0020	45.0
570000	3188GH574U015DP	3.000 × 5.625	0.0019	45.0
960000	3188GN964U015DP	3.000 × 8.625	0.0016	45.0

20.0 VDC Working 30.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
22000	3188BA223U020AP	1.375 × 2.125	0.0349	6.5
26000	3188BB263U020AP	1.375 × 2.625	0.0297	7.6
35000	3188BC353U020AP	1.375 × 3.125	0.0233	9.2
44000	3188BD443U020AP	1.375 × 3.625	0.0195	10.7
53000	3188BE533U020AP	1.375 × 4.125	0.0170	12.1
62000	3188BF623U020AP	1.375 × 4.625	0.0067	20.2
71000	3188BG713U020AP	1.375 × 5.125	0.0062	22.0
80000	3188BH803U020AP	1.375 × 5.625	0.0058	23.7
39000	3188DA393U020AP	1.750 × 2.125	0.0167	10.9
47000	3188DB473U020AP	1.750 × 2.625	0.0142	12.7
63000	3188DC633U020AP	1.750 × 3.125	0.0112	15.3
79000	3188DD793U020AP	1.750 × 3.625	0.0094	17.7
95000	3188DE953U020AP	1.750 × 4.125	0.0083	20.0
110000	3188DF114U020AP	1.750 × 4.625	0.0075	22.0
120000	3188DG124U020AP	1.750 × 5.125	0.0069	23.9
140000	3188DH144U020AP	1.750 × 5.625	0.0065	25.8
51000	3188EA513U020AP	2.000 × 2.125	0.0106	14.9
61000	3188EB613U020AP	2.000 × 2.625	0.0091	17.3
82000	3188EC823U020AP	2.000 × 3.125	0.0072	20.7
100000	3188ED104U020AP	2.000 × 3.625	0.0061	23.9
120000	3188EE124U020AP	2.000 × 4.125	0.0054	26.8
140000	3188EF144U020AP	2.000 × 4.625	0.0049	29.4
160000	3188EG164U020AP	2.000 × 5.125	0.0045	30.0
180000	3188EH184U020AP	2.000 × 5.625	0.0043	30.0
100000	3188FB104U020AP	2.500 × 2.625	0.0075	22.0
130000	3188FC134U020AP	2.500 × 3.125	0.0060	26.3
170000	3188FD174U020DP	2.500 × 3.625	0.0050	30.2
200000	3188FE204U020DP	2.500 × 4.125	0.0044	33.8
230000	3188FF234U020DP	2.500 × 4.625	0.0040	37.2
270000	3188FG274U020DP	2.500 × 5.125	0.0037	40.3
300000	3188FH304U020DP	2.500 × 5.625	0.0035	43.2
200000	3188GC204U020DP	3.000 × 3.125	0.0040	36.2
250000	3188GD254U020DP	3.000 × 3.625	0.0034	41.4
300000	3188GE304U020DP	3.000 × 4.125	0.0030	45.0
350000	3188GF354U020DP	3.000 × 4.625	0.0027	45.0
400000	3188GG404U020DP	3.000 × 5.125	0.0025	45.0
450000	3188GH454U020DP	3.000 × 5.625	0.0024	45.0
750000	3188GN754U020DP	3.000 × 8.625	0.0019	45.0

25.0 VDC Working 40.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
17000	3188BA173U025AP	1.375 × 2.125	0.0353	6.4
20000	3188BB203U025AP	1.375 × 2.625	0.0301	7.6
27000	3188BC273U025AP	1.375 × 3.125	0.0236	9.2
34000	3188BD343U025AP	1.375 × 3.625	0.0197	10.6
40000	3188BE403U025AP	1.375 × 4.125	0.0172	12.0
47000	3188BF473U025AP	1.375 × 4.625	0.0155	13.3
54000	3188BG543U025AP	1.375 × 5.125	0.0142	14.6
61000	3188BH613U025AP	1.375 × 5.625	0.0132	15.7
30000	3188DA303U025AP	1.750 × 2.125	0.0169	10.8
36000	3188DB363U025AP	1.750 × 2.625	0.0144	12.6
48000	3188DC483U025AP	1.750 × 3.125	0.0114	15.2
60000	3188DD603U025AP	1.750 × 3.625	0.0096	17.6
72000	3188DE723U025AP	1.750 × 4.125	0.0084	19.8

25.0 VDC Working 40.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
84000	3188DF843U025AP	1.750 × 4.625	0.0076	21.9
96000	3188DG963U025AP	1.750 × 5.125	0.0070	23.8
100000	3188DH104U025AP	1.750 × 5.625	0.0066	25.6
39000	3188EA393U025AP	2.000 × 2.125	0.0108	14.8
47000	3188EB473U025AP	2.000 × 2.625	0.0093	17.2
62000	3188EC623U025AP	2.000 × 3.125	0.0073	20.6
78000	3188ED783U025AP	2.000 × 3.625	0.0062	23.7
94000	3188EE943U025AP	2.000 × 4.125	0.0055	26.6
100000	3188EF104U025AP	2.000 × 4.625	0.0086	22.3
120000	3188EG124U025AP	2.000 × 5.125	0.0078	24.3
140000	3188EH144U025AP	2.000 × 5.625	0.0043	30.0
78000	3188FB783U025AP	2.500 × 2.625	0.0076	21.9
100000	3188FC104U025AP	2.500 × 3.125	0.0060	26.1
130000	3188FD134U025DP	2.500 × 3.625	0.0051	30.1
150000	3188FE154U025DP	2.500 × 4.125	0.0045	33.6
180000	3188FF184U025DP	2.500 × 4.625	0.0040	37.0
200000	3188FG204U025DP	2.500 × 5.125	0.0037	40.1
230000	3188FH234U025DP	2.500 × 5.625	0.0035	43.0
150000	3188GC154U025DP	3.000 × 3.125	0.0053	31.5
190000	3188GD194U025DP	3.000 × 3.625	0.0044	36.2
230000	3188GE234U025DP	3.000 × 4.125	0.0039	40.5
260000	3188GF264U025DP	3.000 × 4.625	0.0035	44.4
300000	3188GG304U025DP	3.000 × 5.125	0.0032	45.0
340000	3188GH344U025DP	3.000 × 5.625	0.0030	45.0
570000	3188GN574U025DP	3.000 × 8.625	0.0025	45.0

30.0 VDC Working 45.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
14000	3188BA143U030AP	1.375 × 2.125	0.0357	6.4
17000	3188BB173U030AP	1.375 × 2.625	0.0304	7.5
23000	3188BC233U030AP	1.375 × 3.125	0.0238	9.1
29000	3188BD293U030AP	1.375 × 3.625	0.0199	10.6
35000	3188BE353U030AP	1.375 × 4.125	0.0173	12.0
41000	3188BF413U030AP	1.375 × 4.625	0.0156	13.3
47000	3188BG473U030AP	1.375 × 5.125	0.0143	14.5
53000	3188BH533U030AP	1.375 × 5.625	0.0133	15.7
26000	3188DA263U030AP	1.750 × 2.125	0.0171	10.8
31000	3188DB313U030AP	1.750 × 2.625	0.0146	12.6
42000	3188DC423U030AP	1.750 × 3.125	0.0115	15.2
53000	3188DD533U030AP	1.750 × 3.625	0.0096	17.6
63000	3188DE633U030AP	1.750 × 4.125	0.0084	19.8
74000	3188DF743U030AP	1.750 × 4.625	0.0076	21.8
85000	3188DG853U030AP	1.750 × 5.125	0.0070	23.8
95000	3188DH953U030AP	1.750 × 5.625	0.0066	25.6
34000	3188EA343U030AP	2.000 × 2.125	0.0194	11.0
41000	3188EB413U030AP	2.000 × 2.625	0.0166	12.9
55000	3188EC553U030AP	2.000 × 3.125	0.0130	15.5
68000	3188ED683U030AP	2.000 × 3.625	0.0109	17.9
82000	3188EE823U030AP	2.000 × 4.125	0.0095	20.1
96000	3188EF963U030AP	2.000 × 4.625	0.0086	22.3
110000	3188EG114U030AP	2.000 × 5.125	0.0079	24.2
120000	3188EH124U030AP	2.000 × 5.625	0.0073	26.1
68000	3188FB683U030AP	2.500 × 2.625	0.0077	21.8

30.0 VDC Working 45.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
91000	3188FC913U030AP	2.500 × 3.125	0.0061	26.1
110000	3188FD114U030AP	2.500 × 3.625	0.0051	30.0
130000	3188FE134U030DP	2.500 × 4.125	0.0045	33.5
160000	3188FF164U030DP	2.500 × 4.625	0.0041	36.9
180000	3188FG184U030DP	2.500 × 5.125	0.0038	40.0
200000	3188FH204U030DP	2.500 × 5.625	0.0035	42.9
130000	3188GC134U030DP	3.000 × 3.125	0.0053	31.4
160000	3188GD164U030DP	3.000 × 3.625	0.0045	36.0
200000	3188GE204U030DP	3.000 × 4.125	0.0039	40.4
230000	3188GF234U030DP	3.000 × 4.625	0.0035	44.3
270000	3188GG274U030DP	3.000 × 5.125	0.0032	45.0
300000	3188GH304U030DP	3.000 × 5.625	0.0030	45.0
500000	3188GN504U030DP	3.000 × 8.625	0.0025	45.0

35.0 VDC Working 50.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
12000	3188BA123U035AP	1.375 × 2.125	0.0360	6.4
15000	3188BB153U035AP	1.375 × 2.625	0.0306	7.5
20000	3188BC203U035AP	1.375 × 3.125	0.0239	9.1
25000	3188BD253U035AP	1.375 × 3.625	0.0200	10.6
31000	3188BE313U035AP	1.375 × 4.125	0.0174	12.0
36000	3188BF363U035AP	1.375 × 4.625	0.0157	13.3
41000	3188BG413U035AP	1.375 × 5.125	0.0144	14.5
46000	3188BH463U035AP	1.375 × 5.625	0.0134	15.6
22000	3188DA223U035AP	1.750 × 2.125	0.0172	10.7
27000	3188DB273U035AP	1.750 × 2.625	0.0147	12.5
36000	3188DC363U035AP	1.750 × 3.125	0.0116	15.1
45000	3188DD453U035AP	1.750 × 3.625	0.0097	17.5
55000	3188DE553U035AP	1.750 × 4.125	0.0085	19.7
64000	3188DF643U035AP	1.750 × 4.625	0.0077	21.8
73000	3188DG733U035AP	1.750 × 5.125	0.0071	23.7
82000	3188DH823U035AP	1.750 × 5.625	0.0066	25.5
29000	3188EA293U035AP	2.000 × 2.125	0.0196	11.0
35000	3188EB353U035AP	2.000 × 2.625	0.0167	12.8
47000	3188EC473U035AP	2.000 × 3.125	0.0131	15.4
59000	3188ED593U035AP	2.000 × 3.625	0.0110	17.8
71000	3188EE713U035AP	2.000 × 4.125	0.0096	20.1
83000	3188EF833U035AP	2.000 × 4.625	0.0086	22.2
95000	3188EG953U035AP	2.000 × 5.125	0.0079	24.2
100000	3188EH104U035AP	2.000 × 5.625	0.0074	26.0
59000	3188FB593U035AP	2.500 × 2.625	0.0119	17.5
79000	3188FC793U035AP	2.500 × 3.125	0.0093	21.0
99000	3188FD993U035AP	2.500 × 3.625	0.0078	24.2
110000	3188FE114U035AP	2.500 × 4.125	0.0069	27.2
130000	3188FF134U035AP	2.500 × 4.625	0.0062	30.0
150000	3188FG154U035DP	2.500 × 5.125	0.0056	32.6
170000	3188FH174U035DP	2.500 × 5.625	0.0053	35.1
110000	3188GC114U035DP	3.000 × 3.125	0.0053	31.3
140000	3188GD144U035DP	3.000 × 3.625	0.0045	35.9
170000	3188GE174U035DP	3.000 × 4.125	0.0039	40.2
200000	3188GF204U035DP	3.000 × 4.625	0.0035	44.2
230000	3188GG234U035DP	3.000 × 5.125	0.0033	45.0
260000	3188GH264U035DP	3.000 × 5.625	0.0031	45.0
430000	3188GN434U035DP	3.000 × 8.625	0.0025	45.0

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40.0 VDC Working 55.0 Surge

Capacitance μF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
9900	3188BA992U040AP	1.375 × 2.125	0.0365	6.3
11000	3188BB113U040AP	1.375 × 2.625	0.0312	7.4
15000	3188BC153U040AP	1.375 × 3.125	0.0244	9.0
19000	3188BD193U040AP	1.375 × 3.625	0.0204	10.5
23000	3188BE233U040AP	1.375 × 4.125	0.0177	11.9
27000	3188BF273U040AP	1.375 × 4.625	0.0159	13.2
31000	3188BG313U040AP	1.375 × 5.125	0.0146	14.4
35000	3188BH353U040AP	1.375 × 5.625	0.0136	15.5
17000	3188DA173U040AP	1.750 × 2.125	0.0176	10.6
21000	3188DB213U040AP	1.750 × 2.625	0.0150	12.4
28000	3188DC283U040AP	1.750 × 3.125	0.0118	15.0
35000	3188DD353U040AP	1.750 × 3.625	0.0099	17.3
42000	3188DE423U040AP	1.750 × 4.125	0.0086	19.5
49000	3188DF493U040AP	1.750 × 4.625	0.0078	21.6
56000	3188DG563U040AP	1.750 × 5.125	0.0072	23.5
63000	3188DH633U040AP	1.750 × 5.625	0.0067	25.3
22000	3188EA223U040AP	2.000 × 2.125	0.0199	10.9
27000	3188EB273U040AP	2.000 × 2.625	0.0169	12.7
36000	3188EC363U040AP	2.000 × 3.125	0.0133	15.3
45000	3188ED453U040AP	2.000 × 3.625	0.0111	17.7
54000	3188EE543U040AP	2.000 × 4.125	0.0097	20.0
64000	3188EF643U040AP	2.000 × 4.625	0.0087	22.1
73000	3188EG733U040AP	2.000 × 5.125	0.0080	24.0
82000	3188EH823U040AP	2.000 × 5.625	0.0075	25.9
45000	3188FB453U040AP	2.500 × 2.625	0.0121	17.4
61000	3188FC613U040AP	2.500 × 3.125	0.0094	20.9
76000	3188FD763U040AP	2.500 × 3.625	0.0079	24.1
91000	3188FE913U040AP	2.500 × 4.125	0.0069	27.1
100000	3188FF104U040AP	2.500 × 4.625	0.0062	29.8
120000	3188FG124U040DP	2.500 × 5.125	0.0057	32.5
130000	3188FH134U040DP	2.500 × 5.625	0.0053	34.9
90000	3188GC903U040AP	3.000 × 3.125	0.0076	26.3
110000	3188GD114U040DP	3.000 × 3.625	0.0064	30.2
130000	3188GE134U040DP	3.000 × 4.125	0.0055	33.9
150000	3188GF154U040DP	3.000 × 4.625	0.0050	37.3
180000	3188GG184U040DP	3.000 × 5.125	0.0046	40.6
200000	3188GH204U040DP	3.000 × 5.625	0.0042	43.6
330000	3188GN334U040DP	3.000 × 8.625	0.0033	45.0

50.0 VDC Working 75.0 Surge

Capacitance μF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
8300	3188BA832U050AP	1.375 × 2.125	0.0370	6.3
9900	3188BB992U050AP	1.375 × 2.625	0.0314	7.4
13000	3188BC133U050AP	1.375 × 3.125	0.0246	9.0
16000	3188BD163U050AP	1.375 × 3.625	0.0206	10.4
19000	3188BE193U050AP	1.375 × 4.125	0.0180	11.8
23000	3188BF233U050AP	1.375 × 4.625	0.0161	13.1
26000	3188BG263U050AP	1.375 × 5.125	0.0147	14.3
29000	3188BH293U050AP	1.375 × 5.625	0.0137	15.4
14000	3188DA143U050AP	1.750 × 2.125	0.0179	10.5
17000	3188DB173U050AP	1.750 × 2.625	0.0152	12.3
23000	3188DC233U050AP	1.750 × 3.125	0.0120	14.9
29000	3188DD293U050AP	1.750 × 3.625	0.0100	17.2
35000	3188DE353U050AP	1.750 × 4.125	0.0088	19.4

50.0 VDC Working 75.0 Surge *(continued)*

Capacitance μF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
41000	3188DF413U050AP	1.750 × 4.625	0.0079	21.4
47000	3188DG473U05APP	1.750 × 5.125	0.0073	23.4
53000	3188DH533U050AP	1.750 × 5.625	0.0068	25.2
19000	3188EA193U050AP	2.000 × 2.125	0.0201	10.8
22000	3188EB223U050AP	2.000 × 2.625	0.0171	12.6
30000	3188EC303U050AP	2.000 × 3.125	0.0134	15.2
38000	3188ED383U050AP	2.000 × 3.625	0.0112	17.6
45000	3188EE453U050AP	2.000 × 4.125	0.0098	19.9
53000	3188EF533U050AP	2.000 × 4.625	0.0088	22.0
61000	3188EG613U050AP	2.000 × 5.125	0.0081	23.9
68000	3188EH683U050AP	2.000 × 5.625	0.0075	25.8
38000	3188FB383U050AP	2.500 × 2.625	0.0122	17.3
51000	3188FC513U050AP	2.500 × 3.125	0.0095	20.8
63000	3188FD633U050AP	2.500 × 3.625	0.0080	24.0
76000	3188FE763U050AP	2.500 × 4.125	0.0070	27.0
89000	3188FF893U050AP	2.500 × 4.625	0.0063	29.8
100000	3188FG104U050DP	2.500 × 5.125	0.0057	32.4
110000	3188FH114U050DP	2.500 × 5.625	0.0053	34.8
75000	3188GC753U050AP	3.000 × 3.125	0.0076	26.2
94000	3188GD943U050DP	3.000 × 3.625	0.0064	30.1
110000	3188GE114U050DP	3.000 × 4.125	0.0056	33.8
130000	3188GF134U050DP	3.000 × 4.625	0.0050	37.2
150000	3188GG154U050DP	3.000 × 5.125	0.0046	40.4
160000	3188GH164U050DP	3.000 × 5.625	0.0043	43.4
280000	3188GN284U050DP	3.000 × 8.625	0.0034	45.0

60.0 VDC Working 90.0 Surge

Capacitance μF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
6000	3188BA602U060AP	1.375 × 2.125	0.0449	5.7
7200	3188BB722U060AP	1.375 × 2.625	0.0380	6.7
9600	3188BC962U060AP	1.375 × 3.125	0.0295	8.2
12000	3188BD123U060AP	1.375 × 3.625	0.0245	9.5
14000	3188BE143U060AP	1.375 × 4.125	0.0213	10.8
16000	3188BF163U060AP	1.375 × 4.625	0.0190	12.0
19000	3188BG193U060AP	1.375 × 5.125	0.0172	13.2
21000	3188BH213U060AP	1.375 × 5.625	0.0159	14.3
10000	3188DA103U060AP	1.750 × 2.125	0.0645	5.5
12000	3188DB123U060AP	1.750 × 2.625	0.0544	6.5
17000	3188DC173U060AP	1.750 × 3.125	0.0143	13.6
21000	3188DD213U060AP	1.750 × 3.625	0.0119	15.8
25000	3188DE253U060AP	1.750 × 4.125	0.0103	17.9
30000	3188DF303U060AP	1.750 × 4.625	0.0092	19.9
34000	3188DG343U060AP	1.750 × 5.125	0.0084	21.7
38000	3188DH383U060AP	1.750 × 5.625	0.0078	23.4
13000	3188EA133U060AP	2.000 × 2.125	0.0245	9.8
16000	3188EB163U060AP	2.000 × 2.625	0.0207	11.5
22000	3188EC223U060AP	2.000 × 3.125	0.0161	13.9
27000	3188ED273U060AP	2.000 × 3.625	0.0134	16.1
33000	3188EE333U060AP	2.000 × 4.125	0.0116	18.3
38000	3188EF383U060AP	2.000 × 4.625	0.0103	20.2
44000	3188EG443U060AP	2.000 × 5.125	0.0094	22.1
50000	3188EH503U060AP	2.000 × 5.625	0.0087	23.9
24000	3188FB243U060AP	2.500 × 2.625	0.0275	11.5
32000	3188FC323U060AP	2.500 × 3.125	0.0212	13.9

60.0 VDC Working 90.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
40000	3188FD403U060AP	2.500 × 3.625	0.0175	16.2
48000	3188FE483U060AP	2.500 × 4.125	0.0151	18.3
56000	3188FF563U060AP	2.500 × 4.625	0.0133	20.4
64000	3188FG643U060AP	2.500 × 5.125	0.0121	22.3
73000	3188FH733U060AP	2.500 × 5.625	0.0111	24.2
47000	3188GC473U060AP	3.000 × 3.125	0.0141	19.2
59000	3188GD593U060AP	3.000 × 3.625	0.0117	22.3
71000	3188GE713U060AP	3.000 × 4.125	0.0101	25.2
83000	3188GF833U060AP	3.000 × 4.625	0.0089	27.9
95000	3188GG953U060DP	3.000 × 5.125	0.0081	30.5
100000	3188GH104U060DP	3.000 × 5.625	0.0075	32.9
170000	3188GN174U060DP	3.000 × 8.625	0.0055	45.0

75.0 VDC Working 100.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
4000	3188BA402U075AP	1.375 × 2.125	0.0470	5.6
4800	3188BB482U075AP	1.375 × 2.625	0.0398	6.6
6400	3188BC642U075AP	1.375 × 3.125	0.0309	8.0
8000	3188BD802U075AP	1.375 × 3.625	0.0256	9.3
9700	3188BE972U075AP	1.375 × 4.125	0.0221	10.6
11000	3188BF113U075AP	1.375 × 4.625	0.0197	11.8
12000	3188BG123U075AP	1.375 × 5.125	0.0180	12.9
14000	3188BH143U075AP	1.375 × 5.625	0.0166	14.1
7100	3188DA712U075AP	1.750 × 2.125	0.0657	5.5
8600	3188DB862U075AP	1.750 × 2.625	0.0554	6.5
11000	3188DC113U075AP	1.750 × 3.125	0.0428	7.9
14000	3188DD143U075AP	1.750 × 3.625	0.0351	9.2
17000	3188DE173U075AP	1.750 × 4.125	0.0301	10.5
20000	3188DF203U075AP	1.750 × 4.625	0.0265	11.7
22000	3188DG223U075AP	1.750 × 5.125	0.0240	12.9
25000	3188DH253U075AP	1.750 × 5.625	0.0219	14.0
9300	3188EA932U075AP	2.000 × 2.125	0.0253	9.7
11000	3188EB113U075AP	2.000 × 2.625	0.0215	11.3
14000	3188EC143U075AP	2.000 × 3.125	0.0168	13.6
18000	3188ED183U075AP	2.000 × 3.625	0.0139	15.9
22000	3188EE223U075AP	2.000 × 4.125	0.0120	18.0
26000	3188EF263U075AP	2.000 × 4.625	0.0107	19.9
29000	3188EG293U075AP	2.000 × 5.125	0.0097	21.8
33000	3188EH333U075AP	2.000 × 5.625	0.0090	23.6
16000	3188FB163U075AP	2.500 × 2.625	0.0281	11.4
21000	3188FC213U075AP	2.500 × 3.125	0.0217	13.8
27000	3188FD273U075AP	2.500 × 3.625	0.0179	16.0
32000	3188FE323U075AP	2.500 × 4.125	0.0154	18.1
38000	3188FF383U075AP	2.500 × 4.625	0.0136	20.2
43000	3188FG433U075AP	2.500 × 5.125	0.0123	22.1
48000	3188FH483U075AP	2.500 × 5.625	0.0113	24.0
32000	3188GC323U075AP	3.000 × 3.125	0.0144	19.0
40000	3188GD403U075AP	3.000 × 3.625	0.0119	22.1
48000	3188GE483U075AP	3.000 × 4.125	0.0103	24.9
56000	3188GF563U075AP	3.000 × 4.625	0.0091	27.6
64000	3188GG643U075DP	3.000 × 5.125	0.0092	30.2
72000	3188GH723U075DP	3.000 × 5.625	0.0076	32.6
120000	3188GN124U075DP	3.000 × 8.625	0.0056	45.0

100.0 VDC Working 150.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
1900	3188BA192T100AP	1.375 × 2.125	0.0698	4.6
2300	3188BB232T100AP	1.375 × 2.625	0.0586	5.4
3100	3188BC312T100AP	1.375 × 3.125	0.0448	6.6
3900	3188BD392T100AP	1.375 × 3.625	0.0366	7.8
4700	3188BE472T100AP	1.375 × 4.125	0.0313	8.9
5500	3188BF552T100AP	1.375 × 4.625	0.0275	10.0
6300	3188BG632T100AP	1.375 × 5.125	0.0247	11.0
7100	3188BH712T100AP	1.375 × 5.625	0.0226	12.0
3500	3188DA352T100AP	1.750 × 2.125	0.0735	5.2
4200	3188DB422T100AP	1.750 × 2.625	0.0619	6.1
5600	3188DC562T100AP	1.750 × 3.125	0.0475	7.5
7000	3188DD702T100AP	1.750 × 3.625	0.0390	8.7
8400	3188DE842T100AP	1.750 × 4.125	0.0333	10.0
9800	3188DF982T100AP	1.750 × 4.625	0.0293	11.1
11000	3188DG113T100AP	1.750 × 5.125	0.0264	12.2
12000	3188DH123T100AP	1.750 × 5.625	0.0242	13.3
4500	3188EA452T100AP	2.000 × 2.125	0.0830	5.3
5400	3188EB542T100AP	2.000 × 2.625	0.0699	6.3
7200	3188EC722T100AP	2.000 × 3.125	0.0536	7.6
9100	3188ED912T100AP	2.000 × 3.625	0.0438	8.9
10000	3188EE103T100AP	2.000 × 4.125	0.0377	10.1
12000	3188EF123T100AP	2.000 × 4.625	0.0331	11.3
14000	3188EG143T100AP	2.000 × 5.125	0.0296	12.5
16000	3188EH163T100AP	2.000 × 5.625	0.0270	13.6
9100	3188FB912T100AP	2.500 × 2.625	0.0322	10.6
12000	3188FC123T100AP	2.500 × 3.125	0.0248	12.9
15000	3188FD153T100AP	2.500 × 3.625	0.0204	15.0
18000	3188FE183T100AP	2.500 × 4.125	0.0175	17.0
21000	3188FF213T100AP	2.500 × 4.625	0.0154	19.0
24000	3188FG243T100AP	2.500 × 5.125	0.0139	20.8
27000	3188FH273T100AP	2.500 × 5.625	0.0127	22.6
17000	3188GC173T100AP	3.000 × 3.125	0.0307	13.1
22000	3188GD223T100AP	3.000 × 3.625	0.0250	15.2
26000	3188GE263T100AP	3.000 × 4.125	0.0214	17.2
31000	3188GF313T100AP	3.000 × 4.625	0.0188	19.2
35000	3188GG353T100AP	3.000 × 5.125	0.0168	21.1
40000	3188GH403T100AP	3.000 × 5.625	0.0153	22.9
67000	3188GN673T100DP	3.000 × 8.625	0.0108	32.6

150.0 VDC Working 200.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
1200	3188BA122T150AP	1.375 × 2.125	0.1014	3.8
1400	3188BB142T150AP	1.375 × 2.625	0.0864	4.5
1900	3188BC192T150AP	1.375 × 3.125	0.0652	5.5
2400	3188BD242T150AP	1.375 × 3.625	0.0528	6.5
2900	3188BE292T150AP	1.375 × 4.125	0.0446	7.5
3400	3188BF342T150AP	1.375 × 4.625	0.0389	8.4
3800	3188BG382T150AP	1.375 × 5.125	0.0350	9.3
4300	3188BH432T150AP	1.375 × 5.625	0.0317	10.2
2100	3188DA212T150AP	1.750 × 2.125	0.0913	4.7
2500	3188DB252T150AP	1.750 × 2.625	0.0769	5.5
3400	3188DC342T150AP	1.750 × 3.125	0.0585	6.7
4300	3188DD432T150AP	1.750 × 3.625	0.0476	7.9
5100	3188DE512T150AP	1.750 × 4.125	0.0406	9.0

150.0 VDC Working 200.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
6000	3188DF602T150AP	1.750 × 4.625	0.0355	10.1
6900	3188DG692T150AP	1.750 × 5.125	0.0317	11.2
7700	3188DH772T150AP	1.750 × 5.625	0.0289	12.2
2800	3188EA282T150AP	2.000 × 2.125	0.0962	4.9
3300	3188EB332T150AP	2.000 × 2.625	0.0811	5.8
4400	3188EC442T150AP	2.000 × 3.125	0.0620	7.1
5600	3188ED562T150AP	2.000 × 3.625	0.0505	8.3
6700	3188EE672T150AP	2.000 × 4.125	0.0430	9.5
7800	3188EF782T150AP	2.000 × 4.625	0.0376	10.6
8900	3188EG892T150AP	2.000 × 5.125	0.0168	16.6
10000	3188EH103T150AP	2.000 × 5.625	0.0153	18.1
5600	3188FB562T150AP	2.500 × 2.625	0.1053	5.9
7400	3188FC742T150AP	2.500 × 3.125	0.0803	7.2
9300	3188FD932T150AP	2.500 × 3.625	0.0244	13.7
11000	3188FE113T150AP	2.500 × 4.125	0.0208	15.6
13000	3188FF133T150AP	2.500 × 4.625	0.0182	17.4
14000	3188FG143T150AP	2.500 × 5.125	0.0165	19.1
16000	3188FH163T150AP	2.500 × 5.625	0.0150	20.8
11000	3188GC113T150AP	3.000 × 3.125	0.0339	12.4
13000	3188GD133T150AP	3.000 × 3.625	0.0279	14.4
16000	3188GE163T150AP	3.000 × 4.125	0.0237	16.4
19000	3188GF193T150AP	3.000 × 4.625	0.0207	18.3
22000	3188GG223T150AP	3.000 × 5.125	0.0185	20.1
24000	3188GH243T150AP	3.000 × 5.625	0.0169	21.9
41000	3188GN413T150DP	3.000 × 8.625	0.0117	31.3

200.0 VDC Working 250.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
790	3188BA791T200AP	1.375 × 2.125	0.1158	3.5
940	3188BB941T200AP	1.375 × 2.625	0.0976	4.2
1200	3188BC122T200AP	1.375 × 3.125	0.0760	5.1
1500	3188BD152T200AP	1.375 × 3.625	0.0617	6.0
1800	3188BE182T200AP	1.375 × 4.125	0.0522	6.9
2200	3188BF222T200AP	1.375 × 4.625	0.0443	7.9
2500	3188BG252T200AP	1.375 × 5.125	0.0396	8.7
2800	3188BH282T200AP	1.375 × 5.625	0.0359	9.5
1400	3188DA142T200AP	1.750 × 2.125	0.0994	4.5
1600	3188DB162T200AP	1.750 × 2.625	0.0848	5.2
2200	3188DC222T200AP	1.750 × 3.125	0.0641	6.4
2800	3188DD282T200AP	1.750 × 3.625	0.0519	7.6
3300	3188DE332T200AP	1.750 × 4.125	0.0443	8.6
3900	3188DF392T200AP	1.750 × 4.625	0.0336	9.7
4500	3188DG452T200AP	1.750 × 5.125	0.0344	10.7
5000	3188DH502T200AP	1.750 × 5.625	0.0192	14.9
1800	3188EA182T200AP	2.000 × 2.125	0.1031	4.8
2100	3188EB212T200AP	2.000 × 2.625	0.0872	5.6
2900	3188EC292T200AP	2.000 × 3.125	0.0661	6.9
3600	3188ED362T200AP	2.000 × 3.625	0.0539	8.0
4300	3188EE432T200AP	2.000 × 4.125	0.0459	9.2
5100	3188EF512T200AP	2.000 × 4.625	0.0210	14.2
5800	3188EG582T200AP	2.000 × 5.125	0.0188	15.7
6500	3188EH652T200AP	2.000 × 5.625	0.0171	17.1
3600	3188FB362T200AP	2.500 × 2.625	0.1091	5.8
4800	3188FC482T200AP	2.500 × 3.125	0.0831	7.0

200.0 VDC Working 250.0 Surge *(continued)*

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
6000	3188FD602T200AP	2.500 × 3.625	0.0264	13.2
7300	3188FE732T200AP	2.500 × 4.125	0.0224	15.0
8500	3188FF852T200AP	2.500 × 4.625	0.0196	16.8
9700	3188FG972T200AP	2.500 × 5.125	0.0176	18.5
10000	3188FH103T200AP	2.500 × 5.625	0.0163	19.9
7100	3188GC712T200AP	3.000 × 3.125	0.0357	12.1
8900	3188GD892T200AP	3.000 × 3.625	0.0291	14.1
10000	3188GE103T200AP	3.000 × 4.125	0.0250	15.9
12000	3188GF123T200AP	3.000 × 4.625	0.0218	17.8
14000	3188GG143T200AP	3.000 × 5.125	0.0194	19.6
16000	3188GH163T200AP	3.000 × 5.625	0.0176	21.4
26000	3188GN263T200DP	3.000 × 8.625	0.0122	30.6

250.0 VDC Working 300.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
520	3188BA521T250AP	1.375 × 2.125	0.1197	3.5
630	3188BB631T250AP	1.375 × 2.625	0.0999	4.1
840	3188BC841T250AP	1.375 × 3.125	0.0759	5.1
1000	3188BD102T250AP	1.375 × 3.625	0.0633	5.9
1200	3188BE122T250AP	1.375 × 4.125	0.0535	6.8
1400	3188BF142T250AP	1.375 × 4.625	0.0466	7.7
1600	3188BG162T250AP	1.375 × 5.125	0.0414	8.5
1800	3188BH182T250AP	1.375 × 5.625	0.0374	9.3
930	3188DA931T250AP	1.750 × 2.125	0.1013	4.4
1100	3188DB112T250AP	1.750 × 2.625	0.0855	5.2
1400	3188DC142T250AP	1.750 × 3.125	0.0662	6.3
1800	3188DD182T250AP	1.750 × 3.625	0.0534	7.5
2200	3188DE222T250AP	1.750 × 4.125	0.0451	8.6
2600	3188DF262T250AP	1.750 × 4.625	0.0393	9.6
2900	3188DG292T250AP	1.750 × 5.125	0.0353	10.6
3300	3188DH332T250AP	1.750 × 5.625	0.0198	14.7
1200	3188EA122T250AP	2.000 × 2.125	0.1045	4.7
1400	3188EB142T250AP	2.000 × 2.625	0.0885	5.6
1900	3188EC192T250AP	2.000 × 3.125	0.0672	6.8
2400	3188ED242T250AP	2.000 × 3.625	0.0547	8.0
2900	3188EE292T250AP	2.000 × 4.125	0.0464	9.1
3300	3188EF332T250AP	2.000 × 4.625	0.0218	14.0
3800	3188EG382T250AP	2.000 × 5.125	0.0194	15.4
4300	3188EH432T250AP	2.000 × 5.625	0.0175	16.9
2400	3188FB242T250AP	2.500 × 2.625	0.1099	5.8
3200	3188FC322T250AP	2.500 × 3.125	0.0329	11.2
4000	3188FD402T250AP	2.500 × 3.625	0.0268	13.1
4800	3188FE482T250AP	2.500 × 4.125	0.0228	14.9
5600	3188FF562T250AP	2.500 × 4.625	0.0200	16.6
6400	3188FG642T250AP	2.500 × 5.125	0.0179	18.3
7300	3188FH732T250AP	2.500 × 5.625	0.0162	20.0
4700	3188GC472T250AP	3.000 × 3.125	0.0361	12.0
5900	3188GD592T250AP	3.000 × 3.625	0.0294	14.0
7100	3188GE712T250AP	3.000 × 4.125	0.0250	15.9
8300	3188GF832T250AP	3.000 × 4.625	0.0219	17.8
9500	3188GG952T250AP	3.000 × 5.125	0.0196	19.6
10000	3188GH103T250AP	3.000 × 5.625	0.0180	21.2
14000	3188GN143T250AP	3.000 × 8.625	0.0143	28.3

300.0 VDC Working 350.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
430	3188BA431T300AP	1.375 × 2.125	0.1295	3.4
510	3188BB511T300AP	1.375 × 2.625	0.1094	4.0
680	3188BC681T300AP	1.375 × 3.125	0.0830	4.9
860	3188BD861T300AP	1.375 × 3.625	0.0668	5.8
1000	3188BE102T300AP	1.375 × 4.125	0.0575	6.6
1200	3188BF122T300AP	1.375 × 4.625	0.0492	7.5
1300	3188BG132T300AP	1.375 × 5.125	0.0451	8.2
1500	3188BH152T300AP	1.375 × 5.625	0.0401	9.0
760	3188DA761T300AP	1.750 × 2.125	0.1075	4.3
920	3188DB921T300AP	1.750 × 2.625	0.0899	5.1
1200	3188DC122T300AP	1.750 × 3.125	0.0691	6.2
1500	3188DD152T300AP	1.750 × 3.625	0.0562	7.3
1800	3188DE182T300AP	1.750 × 4.125	0.0477	8.3
2100	3188DF212T300AP	1.750 × 4.625	0.0416	9.3
2400	3188DG242T300AP	1.750 × 5.125	0.0238	12.9
2700	3188DH272T300AP	1.750 × 5.625	0.0215	14.1
990	3188EA991T300AP	2.000 × 2.125	0.1090	4.6
1100	3188EB112T300AP	2.000 × 2.625	0.0937	5.4
1500	3188EC152T300AP	2.000 × 3.125	0.0710	6.6
1900	3188ED192T300AP	2.000 × 3.625	0.0575	7.8
2300	3188EE232T300AP	2.000 × 4.125	0.0270	12.0
2700	3188EF272T300AP	2.000 × 4.625	0.0235	13.4
3100	3188EG312T300AP	2.000 × 5.125	0.0209	14.9
3500	3188EH352T300AP	2.000 × 5.625	0.0189	16.3
1900	3188FB192T300AP	2.500 × 2.625	0.1129	5.7
2600	3188FC262T300AP	2.500 × 3.125	0.0347	10.9
3300	3188FD332T300AP	2.500 × 3.625	0.0282	12.8
3900	3188FE392T300AP	2.500 × 4.125	0.0241	14.5
4600	3188FF462T300AP	2.500 × 4.625	0.0210	16.2
5300	3188FG532T300AP	2.500 × 5.125	0.0187	17.9
5900	3188FH592T300AP	2.500 × 5.625	0.0170	19.5
3900	3188GC392T300AP	3.000 × 3.125	0.0372	11.9
4900	3188GD492T300AP	3.000 × 3.625	0.0303	13.8
5800	3188GE582T300AP	3.000 × 4.125	0.0258	15.7
6800	3188GF682T300AP	3.000 × 4.625	0.0226	17.5
7800	3188GG782T300AP	3.000 × 5.125	0.0201	19.3
8800	3188GH882T300AP	3.000 × 5.625	0.0183	21.0
11000	3188GN113T300AP	3.000 × 8.625	0.0148	27.8

350.0 VDC Working 400.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
350	3188BA351T350AP	1.375 × 2.125	0.2781	2.3
420	3188BB421T350AP	1.375 × 2.625	0.2324	2.7
570	3188BC571T350AP	1.375 × 3.125	0.1728	3.4
710	3188BD711T350AP	1.375 × 3.625	0.1395	4.0
850	3188BE851T350AP	1.375 × 4.125	0.1172	4.6
900	3188BF901T350AP	1.375 × 4.625	0.1097	5.0
1100	3188BG112T350AP	1.375 × 5.125	0.0914	5.7
1200	3188BH122T350AP	1.375 × 5.625	0.0840	6.2
630	3188DA631T350AP	1.750 × 2.125	0.1815	3.3
760	3188DB761T350AP	1.750 × 2.625	0.1515	3.9
1000	3188DC102T350AP	1.750 × 3.125	0.1156	4.8
1200	3188DD122T350AP	1.750 × 3.625	0.0956	5.6
1500	3188DE152T350AP	1.750 × 4.125	0.0787	6.5

350.0 VDC Working 400.0 Surge *(continued)*

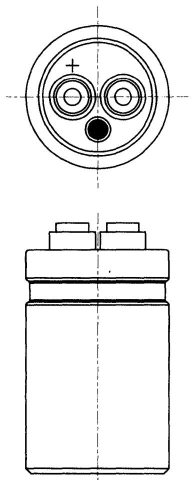
Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
1700	3188DF172T350AP	1.750 × 4.625	0.0577	7.9
2000	3188DG202T350AP	1.750 × 5.125	0.0496	8.9
2200	3188DH222T350AP	1.750 × 5.625	0.0453	9.7
820	3188EA821T350AP	2.000 × 2.125	0.1616	3.8
980	3188EB981T350AP	2.000 × 2.625	0.1356	4.5
1300	3188EC132T350AP	2.000 × 3.125	0.1030	5.5
1600	3188ED162T350AP	2.000 × 3.625	0.0839	6.4
1900	3188EE192T350AP	2.000 × 4.125	0.0539	8.5
2300	3188EF232T350AP	2.000 × 4.625	0.0453	9.7
2600	3188EG262T350AP	2.000 × 5.125	0.0404	10.7
2900	3188EH292T350AP	2.000 × 5.625	0.0365	11.7
1300	3188FB132T350AP	2.500 × 2.625	0.1422	5.1
1800	3188FC182T350AP	2.500 × 3.125	0.0692	7.7
2200	3188FD222T350AP	2.500 × 3.625	0.0568	9.0
2700	3188FE272T350AP	2.500 × 4.125	0.0471	10.4
3100	3188FF312T350AP	2.500 × 4.625	0.0412	11.6
3600	3188FG362T350AP	2.500 × 5.125	0.0361	12.9
4000	3188FH402T350AP	2.500 × 5.625	0.0327	14.1
2600	3188GC262T350AP	3.000 × 3.125	0.0564	9.6
3300	3188GD332T350AP	3.000 × 3.625	0.0454	11.3
4000	3188GE402T350AP	3.000 × 4.125	0.0382	12.9
4700	3188GF472T350AP	3.000 × 4.625	0.0331	14.5
5300	3188GG532T350AP	3.000 × 5.125	0.0295	15.9
6000	3188GH602T350AP	3.000 × 5.625	0.0265	17.4
10000	3188GN103T350AP	3.000 × 8.625	0.0175	25.6

400.0 VDC Working 450.0 Surge

Capacitance µF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
310	3188BA311T400AP	1.375 × 2.125	0.2886	2.2
370	3188BB371T400AP	1.375 × 2.625	0.2422	2.7
500	3188BC501T400AP	1.375 × 3.125	0.1807	3.3
620	3188BD621T400AP	1.375 × 3.625	0.1464	3.9
750	3188BE751T400AP	1.375 × 4.125	0.1219	4.5
870	3188BF871T400AP	1.375 × 4.625	0.1057	5.1
1000	3188BG102T400AP	1.375 × 5.125	0.0927	5.7
1100	3188BH112T400AP	1.375 × 5.625	0.0846	6.2
550	3188DA551T400AP	1.750 × 2.125	0.1891	3.2
670	3188DB671T400AP	1.750 × 2.625	0.1569	3.8
890	3188DC891T400AP	1.750 × 3.125	0.1190	4.7
1100	3188DD112T400AP	1.750 × 3.625	0.0968	5.5
1300	3188DE132T400AP	1.750 × 4.125	0.0690	6.9
1500	3188DF152T400AP	1.750 × 4.625	0.0601	7.8
1700	3188DG172T400AP	1.750 × 5.125	0.0533	8.6
2000	3188DH202T400AP	1.750 × 5.625	0.0459	9.7
720	3188EA721T400AP	2.000 × 2.125	0.1671	3.8
860	3188EB861T400AP	2.000 × 2.625	0.1403	4.4
1100	3188EC112T400AP	2.000 × 3.125	0.1081	5.4
1400	3188ED142T400AP	2.000 × 3.625	0.0666	7.2
1700	3188EE172T400AP	2.000 × 4.125	0.0554	8.4
2000	3188EF202T400AP	2.000 × 4.625	0.0476	9.4
2300	3188EG232T400AP	2.000 × 5.125	0.0418	10.5
2600	3188EH262T400AP	2.000 × 5.625	0.0374	11.6
1200	3188FB122T400AP	2.500 × 2.625	0.1438	5.0
1600	3188FC162T400AP	2.500 × 3.125	0.0711	7.6

400.0 VDC Working 450.0 Surge *(continued)*

Capacitance μF	Philips Components Part Number	Nominal Case Size Inch D × L	Maximum ESR OHMS 120 Hz, 25C	Max. RMS Ripple Current Amps at 120 Hz, 85C
2000	3188FD202T400AP	2.500 × 3.625	0.0574	8.9
2400	3188FE242T400AP	2.500 × 4.125	0.0493	10.2
2800	3188FF282T400AP	2.500 × 4.625	0.0418	11.5
3200	3188FG322T400AP	2.500 × 5.125	0.0370	12.7
3600	3188FH362T400AP	2.500 × 5.625	0.0332	14.0
2300	3188GC232T400AP	3.000 × 3.125	0.0579	9.5
2900	3188GD292T400AP	3.000 × 3.625	0.0467	11.1
3500	3188GE352T400AP	3.000 × 4.125	0.0393	12.7
4100	3188GF412T400AP	3.000 × 4.625	0.0341	14.3
4700	3188GG472T400AP	3.000 × 5.125	0.0302	15.7
5300	3188GH532T400AP	3.000 × 5.625	0.0272	17.2
8800	3188GN882T400AP	3.000 × 8.625	0.0179	25.3



Computer-Grade Aluminum Electrolytic Capacitors

Symmetrical-Tolerance Capacitors for Switch-Mode Power Supplies.

Description

Series 3191 Computer-Grade Aluminum Electrolytic Capacitors are specifically designed for use in switch-mode power supplies. Their construction utilizes the most advanced multiple-tabbing techniques and a non-acqueous electrolyte system to attain extremely low ESR, high ripple-current capability and long life. These same attributes make them an excellent choice for any filtering application.

Features

- Ideal for High Frequency SMPS Output Filtering.
- Symmetrical ESR Tolerance—±30%.
- Symmetrical Capacitance Tolerance—±20%.
- High Ripple Current Capability.

General Specifications

Operating Temperature: −40°C +100.
Voltage Range: 7.5–55VDC.
Capacitance Range: 2800μF–170,000μF.
Capacitance Tolerance: ±20%.
Case Size Range: 1.375″ × 2.125″–2.0″ × 5.625″.
Termination: Screw inserts or solderable terminals.
Life Validation Test: 1500 Hours at +100°C or
3000 Hours at +85°C.
Δ CAP ≤ 15% from Initial Measurement.
Δ ESR ≤ 175% of Initial Measured Limit.
Δ DCL ≤ 100% of Initial Specification Limit.
Shelf Test: 100 Hours at +85°C.
Δ CAP ≤ 100% of Original Specification.
Δ ESR ≤ 100% of Original Specification.
Δ DCL ≤ 100% of Original Specification.

Performance Characteristics: See page 95
Life Prediction Guidelines: See page 99
Application Guidelines: See page 105

How to Specify

Philips Components Series Capacitors can be completely specified using the following designation:

XXXX BA 942 M 005 A M A-1

- **XXXX** — Philips Components Product Series
- **BA** — Case Size Code
- **942** — Capacitance
  XX = Significant Digits
  X = Multiplier
  i.e. 942 = 9400μF
- **M** — Tolerance
  M = ±20%
- **005** — Voltage
  005 = 5VDC
  055 = 55VDC
- **A** — Terminal Style
  A = High Post
  B = Low Post
  H = PC Mount
- **M** — Insulation & Bracket Code (see physical spec)
- **A-1** — Factory Assigned Number

Physical Specifications

Insulated Case Dimension Adder And Bracket Codes

Insulation Type	Inches D	Inches L	Inches H	MM D	MM L	MM H	Bracket Code without	Bracket Code with
.004 inch Polymeric	.010	.015	.010	.25	.38	.25	M	L
.008 inch Polymeric	.020	.032	.024	.508	.813	.61	P	R
.012 inch Polymeric	.025	.062	.045	.63	1.58	1.14	H	J
Uninsulated	—	—	—	—	—	—	N	X

Bracket Dimensions

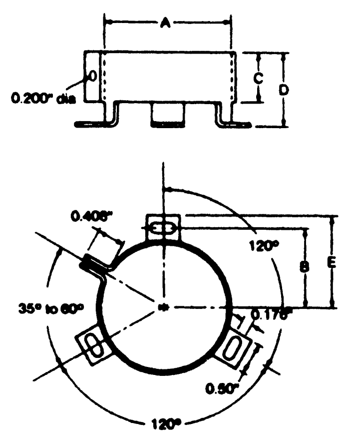
Dimensions in Inches

Case Diameters	A ±0.005	B ±0.031	C ±0.016	D ±0.031	E ±0.031
1.375	1.375	0.906	0.562	0.750	1.156
1.750	1.750	1.125	0.750	1.125	1.313
2.000	2.000	1.250	0.750	1.125	1.438

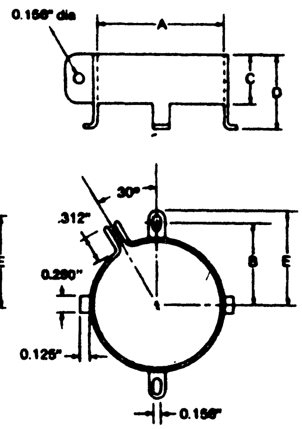
Dimensions in Millimeters

Case Diameters	A ±0.13	B ±0.79	C ±0.40	D ±0.79	E ±0.79
34.92	34.92	23.01	14.25	19.05	29.36
44.45	44.45	28.57	19.05	28.57	33.35
50.80	50.80	31.75	19.05	28.57	36.51

Bracket Outline Drawing



For 1-3/4(D), 2(E), inch diameter can sizes



For 1-3/8(B) inch diameter can sizes

Physical Specifications Computer Grade

Dimensions

Case Code*	Uninsulated Case Dimensions: Dimensions in Inches D	L	S	Dimensions in Millimeters D	L	S
BA	1.375	2.125	.500	34.92	53.97	12.70
BB	1.375	2.625	.500	34.92	66.67	12.70
BC	1.375	3.125	.500	34.92	79.37	12.70
BD	1.375	3.625	.500	34.92	92.07	12.70
BE	1.375	4.125	.500	34.92	104.77	12.70
BF	1.375	4.625	.500	34.92	117.47	12.70
BG	1.375	5.125	.500	34.92	130.17	12.70
BH	1.375	5.625	.500	34.92	142.87	12.70
DA	1.750	2.125	.750	44.45	53.97	19.05
DB	1.750	2.625	.750	44.45	66.67	19.05
DC	1.750	3.125	.750	44.45	79.37	19.05
DD	1.750	3.625	.750	44.45	92.07	19.05
DE	1.750	4.125	.750	44.45	104.77	19.05
DF	1.750	4.625	.750	44.45	117.47	19.05
DG	1.750	5.125	.750	44.45	130.17	19.05
DH	1.750	5.625	.750	44.45	142.87	19.05
EA	2.000	2.125	.875	50.80	53.97	22.22
EB	2.000	2.625	.875	50.80	66.67	22.22
EC	2.000	3.125	.875	50.80	79.37	22.22
ED	2.000	3.625	.875	50.80	92.07	22.22
EE	2.000	4.125	.875	50.80	104.77	22.22
EF	2.000	4.625	.875	50.80	117.47	22.22
EG	2.000	5.125	.875	50.80	130.17	22.22
EH	2.000	5.625	.875	50.80	142.87	22.22

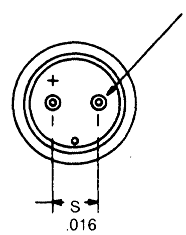
PC Mount Overall Height (Inches)

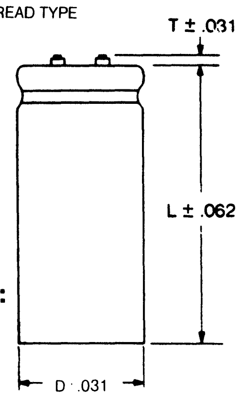
Case Length	H
2.125	2.31
2.625	2.81
3.125	3.31
3.625	3.81
4.125	4.31
4.625	4.81
5.125	5.31
5.625	5.81

PC Mount Terminal Spacing (Inches)

Case Diameter	X	Y	Z
1.375	.550	.500	.375
1.750	.900	.700	.525
2.000	1.000	.800	.575

Case Outline Drawing

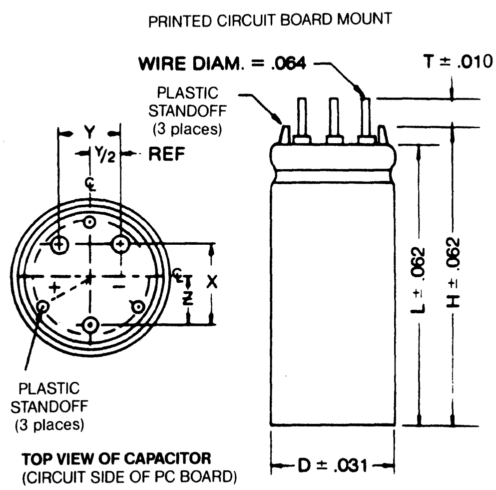




The capacitors are marked with:

- nominal capacitance
- rated voltage
- EIA source and date code
- maximum ambient temperature
- polarity
- name of manufacturer
- part number
- capacitance tolerance

Case Outline Drawing



Terminal Styles, Dimensions, and Code				
Terminal Style	**T (inches)**	**T (mm)**	**Code**	**Thread Type**
High Post	.250	6.4	A	10-32
Low Post	.063	1.6	B	10-32
PC Mount	.250	6.4	H	N/A

**Contact factory for maximum capacitance.
EA can only multiply .8 time capacitance table.

7.5 VDC Working 9.0 Surge

Capacitance µF	Philips Components Part Number	Case Code	Maximum ESR (OHMS) 120Hz,25C	±30% ESR (MOHMS) 20KHZ,25C	Max. RMS Ripple Current Amps at 20KHZ,85C
15000	3191BA153M7P5BP	BA	0.0158	9.6	9.4
21000	3191BB213M7P5BP	BB	0.0131	8.3	10.9
27000	3191BC273M7P5BP	BC	0.0108	7.1	12.7
33000	3191BD333M7P5BP	BD	0.0094	6.4	14.2
39000	3191BE393M7P5BP	BE	0.0086	6.0	15.5
45000	3191BF453M7P5BP	BF	0.0076	5.2	17.5
51000	3191BG513M7P5BP	BG	0.0071	5.0	18.7
57000	3191BH573M7P5BP	BH	0.0068	4.8	19.7
48000	3191EA483M7P5BP	EA	0.0121	7.0	13.9
58000	3191EB583M7P5BP	EB	0.0105	6.2	15.9
76000	3191EC763M7P5BP	EC	0.0085	5.3	18.5
95000	3191ED953M7P5BP	ED	0.0074	4.7	20.7
110000	3191EE114M7P5BP	EE	0.0066	4.3	22.7
130000	3191EF134M7P5BP	EF	0.0061	4.1	24.5
150000	3191EG154M7P5BP	EG	0.0057	3.9	26.1
170000	3191EH174M7P5BP	EH	0.0054	3.8	27.5

10.0 VDC Working 12.0 Surge

Capacitance µF	Philips Components Part Number	Case Code	Maximum ESR (OHMS) 120Hz,25C	±30% ESR (MOHMS) 20KHZ,25C	Max. RMS Ripple Current Amps at 20KHZ,85C
16000	3191BA163M010BP	BA	0.0153	9.3	9.5
19000	3191BB193M010BP	BB	0.0133	8.3	10.9
25000	3191BC253M010BP	BC	0.0109	7.0	12.7
31000	3191BD313M010BP	BD	0.0095	6.3	14.3
38000	3191BE383M010BP	BE	0.0086	5.9	15.6
44000	3191BF443M010BP	BF	0.0075	5.1	17.6
51000	3191BG513M010BP	BG	0.0071	4.9	18.8
57000	3191BH573M010BP	BH	0.0067	4.8	19.9
38000	3191EA383M010BP	EA	0.0119	7.1	13.8
46000	3191EB463M010BP	EB	0.0104	6.3	15.8
61000	3191EC613M010BP	EC	0.0084	5.3	18.4
76000	3191ED763M010BP	ED	0.0073	4.7	20.6
92000	3191EE923M010BP	EE	0.0066	4.4	22.6
100000	3191EF104M010BP	EF	0.0060	4.1	24.3
120000	3191EG124M010BP	EG	0.0057	3.9	26.0
130000	3191EH134M010BP	EH	0.0054	3.8	27.4

16.0 VDC Working 18.0 Surge

Capacitance µF	Philips Components Part Number	Case Code	Maximum ESR (OHMS) 120Hz,25C	±30% ESR (MOHMS) 20KHZ,25C	Max. RMS Ripple Current Amps at 20KHZ,85C
10000	3191BA103M016BP	BA	0.0167	9.6	9.3
14000	3191BB143M016BP	BB	0.0138	8.4	10.9
18000	3191BC183M016BP	BC	0.0113	7.1	12.6
22000	3191BD223M016BP	BD	0.0098	6.4	14.2
26000	3191BE263M016BP	BE	0.0089	6.0	15.5
30000	3191BF303M016BP	BF	0.0079	5.2	17.4
34000	3191BG343M016BP	BG	0.0074	5.0	18.6
38000	3191BH383M016BP	BH	0.0070	4.9	19.7
26000	3191EA263M016BP	EA	0.0121	7.2	13.7
32000	3191EB323M016BP	EB	0.0105	6.4	15.7
43000	3191EC433M016BP	EC	0.0086	5.4	18.3
53000	3191ED533M016BP	ED	0.0074	4.8	20.5
64000	3191EE643M016BP	EE	0.0066	4.4	22.5
75000	3191EF753M016BP	EF	0.0061	4.1	24.3
86000	3191EG863M016BP	EG	0.0057	4.0	25.9
96000	3191EH963M016BP	EH	0.0055	3.8	27.4

20.0 VDC Working 22.0 Surge

Capacitance µF	Philips Components Part Number	Case Code	Maximum ESR (OHMS) 120Hz,25C	±30% ESR (MOHMS) 20KHZ,25C	Max. RMS Ripple Current Amps at 20KHZ,85C
8800	3191BA882M020BP	BA	0.0173	9.8	9.3
12000	3191BB123M020BP	BB	0.0142	8.5	10.8
16000	3191BC163M020BP	BC	0.0115	7.2	12.6
20000	3191BD203M020BP	BD	0.0100	6.5	14.1
22000	3191BE223M020BP	BE	0.0093	6.1	15.4
27000	3191BF273M020BP	BF	0.0080	5.3	17.4
30000	3191BG303M020BP	BG	0.0075	5.1	18.5
34000	3191BH343M020BP	BH	0.0071	4.9	19.6
23000	3191EA233M020BP	EA	0.0121	7.3	13.7
27000	3191EB273M020BP	EB	0.0105	6.5	15.6
37000	3191EC373M020BP	EC	0.0086	5.4	18.2
46000	3191ED463M020BP	ED	0.0074	4.8	20.5
55000	3191EE553M020BP	EE	0.0066	4.4	22.4
64000	3191EF643M020BP	EF	0.0061	4.2	24.2
74000	3191EG743M020BP	EG	0.0057	4.0	25.8
83000	3191EH833M020BP	EH	0.0055	3.9	27.3

28.0 VDC Working 32.0 Surge

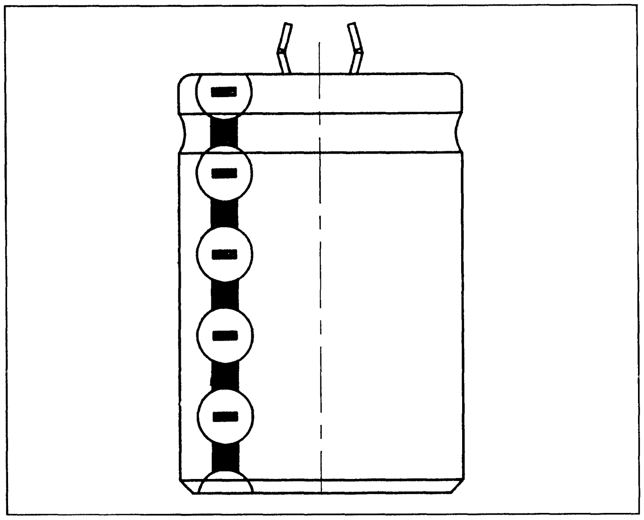
Capacitance µF	Philips Components Part Number	Case Code	Maximum ESR (OHMS) 120Hz,25C	±30% ESR (MOHMS) 20KHZ,25C	Max. RMS Ripple Current Amps at 20KHZ,85C
6300	3191BA632M028BP	BA	0.0213	12.1	8.3
8800	3191BB882M028BP	BB	0.0170	10.1	9.9
11000	3191BC113M028BP	BC	0.0140	8.5	11.6
14000	3191BD143M028BP	BD	0.0119	7.5	13.1
16000	3191BE163M028BP	BE	0.0108	6.9	14.4
19000	3191BF193M028BP	BF	0.0094	6.0	16.2
22000	3191BG223M028BP	BG	0.0086	5.7	17.5
24000	3191BH243M028BP	BH	0.0082	5.5	18.6
15000	3191EA153M028BP	EA	0.0127	7.4	13.5
18000	3191EB183M028BP	EB	0.0110	6.6	15.5
24000	3191EC243M028BP	EC	0.0089	5.5	18.1
30000	3191ED303M028BP	ED	0.0077	4.9	20.3
36000	3191EE363M028BP	EE	0.0069	4.5	22.3
42000	3191EF423M028BP	EF	0.0063	4.2	24.1
48000	3191EG483M028BP	EG	0.0059	4.0	25.7
54000	3191EH543M028BP	EH	0.0056	3.9	27.2

35.0 VDC Working 40.0 Surge

Capacitance µF	Philips Components Part Number	Case Code	Maximum ESR (OHMS) 120Hz,25C	±30% ESR (MOHMS) 20KHZ,25C	Max. RMS Ripple Current Amps at 20KHZ,85C
4500	3191BA452M035BP	BA	0.0235	12.4	8.2
6300	3191BB632M035BP	BB	0.0185	10.4	9.8
8100	3191BC812M035BP	BC	0.0150	8.7	11.5
10000	3191BD103M035BP	BD	0.0129	7.7	13.0
12000	3191BE123M035BP	BE	0.0114	7.0	14.3
14000	3191BF143M035BP	BF	0.0100	6.1	16.1
16000	3191BG163M035BP	BG	0.0092	5.8	17.4
17000	3191BH173M035BP	BH	0.0088	5.6	18.4
11000	3191EA113M035BP	EA	0.0135	7.5	13.4
13000	3191EB133M035BP	EB	0.0116	6.7	15.4
17000	3191EC173M035BP	EC	0.0094	5.6	17.9
22000	3191ED223M035BP	ED	0.0081	4.9	20.2
26000	3191EE263M035BP	EE	0.0072	4.5	22.2
31000	3191EF313M035BP	EF	0.0066	4.3	24.0
35000	3191EG353M035BP	EG	0.0062	4.1	25.6
40000	3191EH403M035BP	EH	0.0058	3.9	27.1

55.0 VDC Working 64.0 Surge

Capacitance µF	Philips Components Part Number	Case Code	Maximum ESR (OHMS) 120Hz,25C	±30% ESR (MOHMS) 20KHZ,25C	Max. RMS Ripple Current Amps at 20KHZ,85C
2800	3191BA282M055BP	BA	0.0302	15.0	7.5
3900	3191BB392M055BP	BB	0.0233	12.3	9.0
5000	3191BC502M055BP	BC	0.0188	10.2	10.6
6200	3191BD622M055BP	BD	0.0159	8.9	12.1
7300	3191BE732M055BP	BE	0.0141	8.1	13.4
8400	3191BF842M055BP	BF	0.0124	7.0	15.0
9500	3191BG952M055BP	BG	0.0114	6.6	16.2
10000	3191BH103M055BP	BH	0.0109	6.4	17.2
7300	3191EA732M055BP	EA	0.0157	8.6	12.6
8800	3191EB882M055BP	EB	0.0135	7.5	14.5
11000	3191EC113M055BP	EC	0.0109	6.3	16.9
14000	3191ED143M055BP	ED	0.0092	5.5	19.1
17000	3191EE173M055BP	EE	0.0082	5.0	21.1
20000	3191EF203M055BP	EF	0.0074	4.7	22.9
23000	3191EG233M055BP	EG	0.0069	4.4	24.6
26000	3191EH263M055BP	EH	0.0065	4.2	26.1



Snap-in Aluminum Electrolytic Capacitors

Description

The Series 3407 utilizes a snap-in terminal configuration. This allows fast and easy mounting onto printed circuit boards, eliminating the need for mounting hardware and reducing assembly time.

This product offers the ability to replace standard 85°C snap ins in all consumer, industrial and professional applications with a high quality domestically manufactured product with all welded construciton.

Features

- High CV Product Value Per Case Size
- High Ripple Current
- Long Life—2000 hr @ 85°C
- All Welded Construction
- For Power Supply Motor Control and UPS Applications
- Voltage Range from 160 to 450VDC

Specifications

Item	Performance Characteristics
Rated Working Voltage Range*	160 ~ 450V
Operating Temperature Range	−40°C ~ + 85°C
Capacitance Tolerance	±20% (120Hz, +25°C)
Load Life Shelf Life	Test conditions Duration: 2000h Ambient temperature: +85°C Applied voltage: DC voltage with maximum permissible ripple current specified at +85°C (Sum of DC voltage and superimposed peak AC voltage for maximum permissible ripple current should be equal to rated DC working voltage). Post test requirements at +25°C Leakage current: ≤ Initial specified value Capacitance change: ≤ ±20% of initial measured value tan d: ≤ 200% of initial specified value Test conditions Duration: 1000h Ambient temperature: +85°C Applied voltage: (None) Post test conditioning by application of voltage Applied voltage: Rated working voltage Duration: 30 min Ambient temperature: +25°C Discharge after application of voltage: Discharge through a resistor Stabilization time: 24h to 48h after discharge Post test requirements at +25°C (after Post test conditioning) Leakage current: ≤ Initial specified value Capacitance change: ≤ ±20% of initial measured value tan d: ≤ 200% of initial specified value
Stability at Low Temperature	Rated voltage [V]: 160 ~ 250 / 300 ~ 450 Impedance Ratio Z −40°C/Z +25°C: 12 / 24
Ripple Current	Refer to standard products table.
	Frequency [Hz]: 120 / 1k / 10k - 50k Correction factor 160 - 250V: 1.00 / 1.15 / 1.20 (Multiplier) 300 - 450V: 1.00 / 1.10 / 1.15
Ripple Current Correction Factor for Ambient Temperature	Ambient Temperature (°C): 45 / 55 / 65 / 75 / 85 Correction factor (Multiplier): 2.2 / 2.0 / 1.7 / 1.4 / 1.0
Leakage Current	$I \leq 3 \times \sqrt{CV}$ (μA) measured after a 5 minute application of rated working voltage at +25°C (C = nominal capacitance in microfarads, V = rated working voltage in volts)
Tangent of Loss Angle	.15max. (120Hz, +25°C)
Surge Voltage	Rated working voltage [V]: 160 / 200 / 250 / 350 / 400 / 450 Surge voltage [V]: 200 / 250 / 300 / 400 / 450 / 500

Dimensions → DXL (mm)

W.V. →	160				200				250			
Diameter →	**22**	**25**	**30**	**35**	**22**	**25**	**30**	**35**	**22**	**25**	**30**	**35**
Cap(UF)												
220									22x25			
									1.2			
270					22x25				22x30	25x25		
					1.2				1.4	1.4		
330					22x30				22x35	25x30		
					1.5				1.7	1.7		
390	22x25				22x30	25x25			22x40	25x30	30x25	
	1.3				1.6	1.6			1.9	1.8	1.8	
470	22x30	25x25			22x35	25x30			22x45	25x35	30x30	
	1.6	1.6			1.8	1.8			2.2	2.1	2.1	
560	22x35	25x30			22x40	25x35	30x25		22x50	25x40	30x30	35x25
	1.8	1.8			2.1	2.1	1.9		2.5	2.4	2.2	2.1
680	22x40	25x30	30x25		22x45	25x40	30x30			25x45	30x35	35x30
	2.1	2.0	2.0		2.4	2.5	2.3			2.7	2.6	2.5
820	22x45	25x35	30x30			25x45	30x35	35x30			30x40	35x35
	2.4	2.3	2.3			2.8	2.7	2.7			3.0	3.0
1000	22x50	25x40	30x30	35x25			30x40	35x30			30x45	35x40
	2.8	2.6	2.5	2.3			3.1	2.7			3.4	3.4
1200		25x45	30x35	35x30			30x45	35x35				35x45
		3.0	2.9	2.8			3.5	3.1				3.8
1500			30x40	35x35			30x50	35x40				35x50
			3.3	3.3			4.0	3.6				4.2
1800			30x50	35x40				35x45				
			4.0	3.7				4.0				
2200				35x45				35x50				
				4.2				4.5				
2700				35x50								Case Size
				4.6								Allowable ripple

Ripple (A) at 85°C 120Hz

Series 3407

W.V. →	350				400				450			
Diameter →	22	25	30	35	22	25	30	35	22	25	30	35
Cap(UF)												
56									22x25			
									0.5			
68									22x30			
									0.6			
82					22x25				22x30	25x25		
					0.6				0.7	0.7		
100	22x25				22x30				22x35	25x30		
	0.6				0.7				0.8	0.8		
120	22x30	25x25			22x30	25x25			22x40	25x35	30x25	
	0.7	0.7			0.7	0.7			0.9	1.0	0.9	
150	22x35	25x30			22x35	25x30			22x50	25x40	30x30	
	0.8	0.8			0.9	0.9			1.1	1.1	1.1	
180	22x40	25x30	30x25		22x40	25x35				25x45	30x40	35x25
	0.9	0.9	1.0		1.0	1.0				1.3	1.4	1.2
220	22x45	25x35	30x30			25x40	30x30	35x25		25x50	30x40	35x30
	1.1	1.1	1.1			1.2	1.2	1.2		1.5	1.5	1.5
270	22x50	25x40	30x30	35x25		25x45	30x35	35x30			30x45	35x35
	1.3	1.2	1.2	1.3		1.4	1.4	1.4			1.7	1.7
330		25x45	30x35	35x30			30x40	35x30			30x50	35x40
		1.4	1.4	1.4			1.6	1.5			2.0	2.0
390			30x40	35x30			30x45	35x35				35x45
			1.6	1.6			1.8	1.8				2.2
470			30x45	35x35			30x50	35x40				35x50
			1.9	1.8			2.0	2.0				2.5
560				35x40				35x45				
				2.1				2.3				
680				35x45				35x50				
				2.4				2.6				
												Case Size
												Allowable ripple

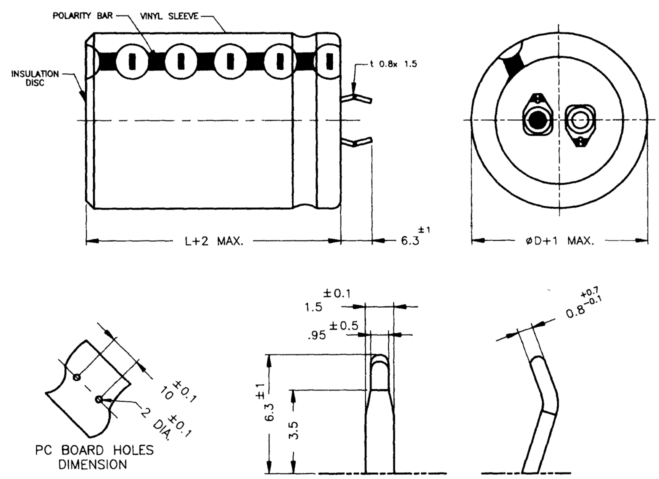
Ripple (A) at 85°C 120Hz

How to Specify

Philips Componets Series Capacitors can be completely specified using the following designation:

3407	DE	102	M	200	D	M
Philips Components Product Series	Case Size Code	Capacitance XX = Significant Digits x = Multiplier i.e. 102 = 1,000 μF	Tolerance M = ±20%	Working Voltage	Cover Construction D = Two leads 10.0mm spacing	Standard Insulation M = .004″ PVC

Dimensions (mm)



	Insulated Case Dimensions			
	Dimensions (mm)		Dimensions (in.)	
Case Codes	**1 D ± mm 0**	**2 L ± mm 0**	**D ± .039 0**	**L ± .079 0**
A B	22	25	.866	.984
A C	22	30	.866	1.181
A D	22	35	.866	1.278
A E	22	40	.866	1.575
A K	22	45	.866	1.772
A F	22	50	.866	1.969
B B	25	25	.984	.984
B C	25	30	.984	1.181
B D	25	35	.984	1.378
B E	25	40	.984	1.575
B K	25	45	.984	1.772
B F	25	50	.984	1.969
C B	30	25	1.181	.984
C C	30	30	1.181	1.181
C D	30	35	1.181	1.378
C E	30	40	1.181	1.575
C K	30	45	1.181	1.772
C F	30	50	1.181	1.969
D B	35	25	1.378	.984
D C	35	30	1.378	1.181
D D	35	35	1.378	1.378
D E	35	40	1.378	1.575
D K	35	45	1.378	1.772
D F	35	50	1.378	1.969.

Capacitor Life Prediction Guidelines:

The following equations can be used to predict the life of aluminum electrolytic capacitors at derated voltages, temperature and ripple current. Failures are defined as parameter drift beyond the requirements outlined in the load life test section.

$$\text{Life} = L_s \cdot 2^{\frac{T_S - [T_A + 5\,(I_A/I_S)^2]}{10}} \cdot \frac{1}{(V_A/V_S)^2}$$

Conditions: $I_A/I_S \leq$ Ripple Current Correction Factor for Ambient Temperature from Page 1.

$T_A \leq T_S$

$$\frac{1}{(V_A/V_S)^2} \leq 1.75$$

Where:

L_S = Specified Load Life Duration [hours]
T_S = Specified Maximum Operating Temperature [°C].
T_A = Ambient Temperature (capacitor surface is regarded as ambient temperature) [°C].
I_A = Applied Ripple Current at operating frequency [A rms].
I_S = Specified maximum ripple current, corrected for frequency [A rms].
V_A = Applied Voltage [Volts]
V_S = Specified Maximum Voltage [Volts]

Capacitor Storage Life Guidelines:

The storage life in hours at lower ambient temperature is as follows:

$$\text{Storage Life} = L \cdot 2^{\frac{T_S - T_A}{10}}$$

Where:
L = Specified Shelf Life Duration [hours]
T_S = Specified Ambient Temperature [°C].
T_A = Actual Storage Temperature Ambient Temperature [°C].

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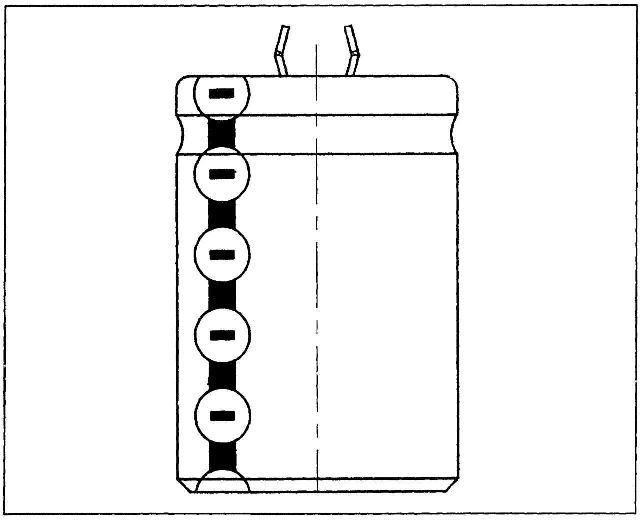


Snap-in Aluminum Electrolytic Capacitors

Description

The Series 3408 utilizes a snap-in terminal configuration. This allows fast and easy mounting onto printed circuit boards, eliminating the need for mounting hardware and reducing assembly time.

This product offers the ability to replace standard 105°C snap ins in all consumer, industrial and professional applications with a high quality domestically manufactured product with all welded construciton.

Features

- High CV Product Value Per Case Size
- High Ripple Current
- Long Life—2000 hrs @ 105°C
- All Welded Construction
- For Power Supply Motor Control and UPS Applications
- Voltage Range from 160 to 250VDC

Specifications

Item	Performance Characteristics
Rated Working Voltage Range*	160 ~ 250V
Operating Temperature Range	−40°C ~ + 105°C
Capacitance Tolerance	±20% (120Hz, +25°C)
Load Life Shelf Life	Test conditions Duration: 2000h Ambient temperature: 105°C Applied voltage: DC voltage with maximum permissible ripple current specified at +85°C (Sum of DC voltage and superimposed peak AC voltage for maximum permissible ripple current should be equal to rated DC working voltage). Post test requirements at +25°C Leakage current: ≤ Initial specified value Capacitance change: ≤ ±20% of initial measured value tan d: ≤ 200% of initial specified value Test conditions Duration: 1000h Ambient temperature: 105°C Applied voltage: (None) Post test conditioning by application of voltage Applied voltage: Rated working voltage Duration: 30 min Ambient temperature: +25°C Discharge after application of voltage: Discharge through a resistor Stabilization time: 24h to 48h after discharge Post test requirements at +25°C (after Post test conditioning) Leakage current: ≤ Initial specified value Capacitance change: ≤ ±20% of initial measured value tan d: ≤ 200% of initial specified value
Stability at Low Temperature	Rated voltage [V] 160 ~ 250 Impedance Ratio Z −40°C/Z +25°C 12 24
Ripple Current	Refer to standard products table.
	Frequency [Hz] 120 / 1k / 10k - 50k Correction factor (Multiplier) 160 - 250V: 1.00 / 1.15 / 1.20 300 - 450V: 1.00 / 1.10 / 1.15
Ripple Current Correction Factor for Ambient Temperature	Ambient Temperature (°C) 45 / 55 / 65 / 75 / 85 Correction factor (Multiplier) 2.2 / 2.0 / 1.7 / 1.4 / 1.0
Leakage Current	I≤3 X $\sqrt{CV}$(μA) measured after a 5 minute application of rated working voltage at +25°C (C = nominal capacitance in microfarads, V = rated working voltage in volts)
Tangent of Loss Angle	.15max. (120Hz, +25°C)
Surge Voltage	Rated working voltage [V] 160 / 200 / 250 Surge voltage [V] 200 / 250 / 300

Dimensions → DXL (mm)

W.V. →	160				200				250			
Diameter →	22	25	30	35	22	25	30	35	22	25	30	35
Cap(UF)												
180									22x25			
									1.14			
220									22x30	25x25		
									1.35	1.33		
270					22x25				22x35	25x30	30x25	
					1.16				1.58	1.59	1.62	
330	22x25				22x30	25x25			22x40	25x35	30x25	
	1.18				1.37	1.36			1.83	1.85	1.70	
390	22x30				22x35	25x30			22x45	25x40	30x30	
	1.39				1.59	1.59			2.08	2.12	2.02	
470	22x35	25x25			22x40	25x30	30x25		22x50	25x40	30x35	35x25
	1.61	1.47			1.83	1.70	1.71		2.36	2.26	2.34	1.98
560	22x40	25x30			22x45	25x35	30x30			25x50	30x35	35x30
	1.85	1.73			2.08	1.97	2.08			2.72	2.45	2.37
680	22x45	25x35	30x25		22x50	25x45	30x30	35x25			30x45	35x35
	2.12	2.02	1.83		2.37	2.42	2.13	1.99			3.04	2.77
820	22x50	25x40	30x30	35x25		25x50	30x35	35x30				35x40
	2.41	2.32	2.18	2.07		2.75	2.47	2.41				3.16
1000		25x45	30x35	35x30			30x45	35x35				35x45
		2.65	2.55	2.49			3.07	2.81				3.56
1200		25x50	30x40	35x30			30x50	35x35				35x50
		2.99	2.91	2.52			3.45	2.86				3.94
1500			30x45	35x35				35x45				
			3.32	2.94				3.61				
1800			30x50	35x45				35x50				
			3.71	3.73				4.00				
2200				35x50								Case Size
				4.14								Allowable ripple

Ripple (A) at 105°C 120Hz

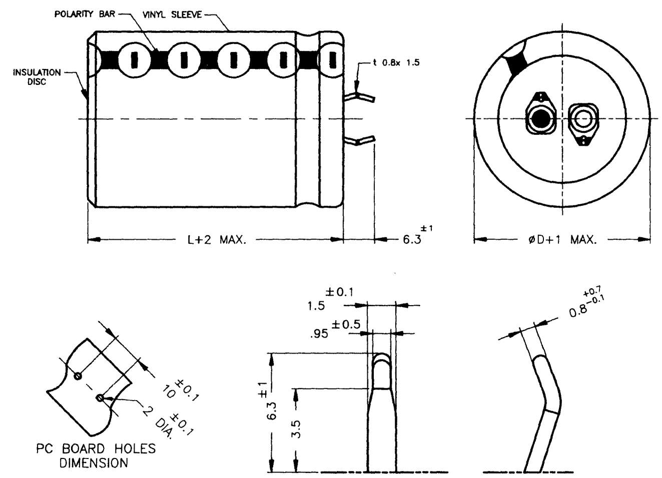
How to Specify

Philips Components Series capacitors can be completely specified using the following designation:

3408	DE	102	M	200	D	F
Philips Components Product Series	Case Size Code	Capacitance XX = Significant Digits x = Multiplier i.e. 102 = 1,000μF	Tolerance M = ±20%	Working Voltage	Cover Construction D = Two leads 10.0mm spacing	Standard Insulation M = .006″ PVC

	Insulated Case Dimensions			
	Dimensions (mm)		Dimensions (in.)	
Case Codes	1 D ± mm 0	2 L ± mm 0	D ± .039 0	L ± .079 0
A B	22	25	.866	.984
A C	22	30	.866	1.181
A D	22	35	.866	1.278
A E	22	40	.866	1.575
A K	22	45	.866	1.772
A F	22	50	.866	1.969
B B	25	25	.984	.984
B C	25	30	.984	1.181
B D	25	35	.984	1.378
B E	25	40	.984	1.575
B K	25	45	.984	1.772
B F	25	50	.984	1.969
C B	30	25	1.181	.984
C C	30	30	1.181	1.181
C D	30	35	1.181	1.378
C E	30	40	1.181	1.575
C K	30	45	1.181	1.772
C F	30	50	1.181	1.969
D B	35	25	1.378	.984
D C	35	30	1.378	1.181
D D	35	35	1.378	1.378
D E	35	40	1.378	1.575
D K	35	45	1.378	1.772
D F	35	50	1.378	1.969

Dimensions (mm)



Capacitor Life Prediciton Guidelines:

The following equations can be used to predict the life of aluminum electrolytic capacitors at derated voltages, temperature and ripple current. Failures are defined as parameter drift beyond the requirements outlined in the load life test section.

$$\text{Life} = L_s \cdot 2^{\frac{T_S - [T_A + 5\,(I_A/I_S)^2]}{10}} \cdot \frac{1}{(V_A/V_S)^2}$$

Conditions: $I_A/I_S \leq$ Ripple Current Correction Factor for Ambient Temperature from Page 1.
$T_A \leq T_S$

$$\frac{1}{(V_A/V_S)^2} \leq 1.75$$

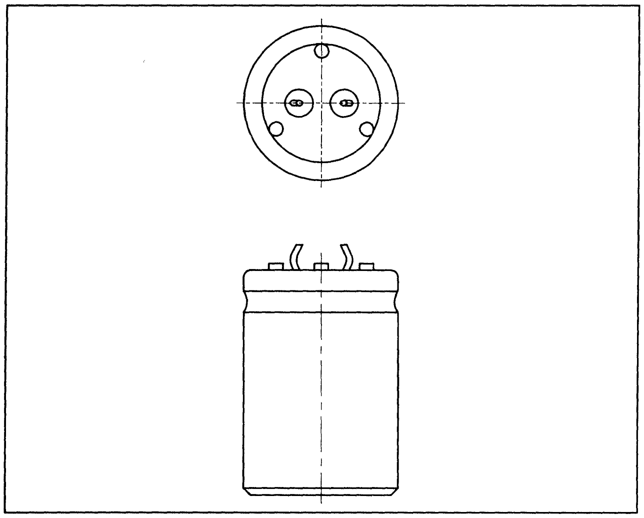
Where:
L_S = Specified Load Life Duration [hours]
T_S = Specified Maximum Operating Temperature [°C].
T_A = Ambient Temperature (capacitor surface is regarded as ambient temperature [°C].
I_A = Applied Ripple Current at operating frequency [A rms].
I_S = Specified maximum ripple current, corrected for frequency [A rms].
V_A = Applied Voltage [Volts]
V_S = Specified Maximum Voltage [Volts]

Capacitor Storage Life Guidelines:

The storage life in hours at lower ambient temperature is as follows:

$$\text{Storage Life} = L \cdot 2^{\frac{T_S - T_A}{10}}$$

Where:
L = Specified Shelf Life Duration [hours]
T_S = Specified Ambient
T_A Temperature [°C].
= Actual Storage Temperature Ambient Temperature [°C].



Industrial/Computer Grade Snap-In Aluminum Electrolytic Capacitors

Description

The Series 3487 utilizes a snap-in terminal configuration. This allows fast and easy mounting onto printed circuit boards, eliminating the need for mounting hardware and reducing assembly time.

A safety vent is integrated into the top of the case, opposite from the terminal end. The possibility of printed circuit board spoilage is thereby reduced.

A plastic coating of the terminal header provides excellent resistance to the entrance of most normally used printed circuit board cleaners.

All connections of the 3487 are welded to insure long-term electrical integrity.

Features

Electrical

- Capacitance from 82 to 120,000 μF.
- Voltage range from 6.3 WVDC to 450 WVDC.
- 85°C ambient operating temperature.
- 2,000-hour life at 85°C with rated DC voltage applied.
- Standard capacitance tolerance ±20%.
- Excellent frequency response.

Mechanical

- Snap-in (self-mounting) terminals
- All welded construction
- Venting mechanism at the top of the case for better printed circuit board protection.
- Pitchless construction (no potting compound).
- Protective plastic end seal to allow on-board cleaning.
- Integral stand off feet on terminal cover for ease of board cleaning.

Performance Characteristics: See page 95
Life Prediction Guidelines: See page 99
Application Guidelines: See page 105

Physical Specifications

How to Specify

Philips Components Series Capacitors can be completely specified using the following designation:

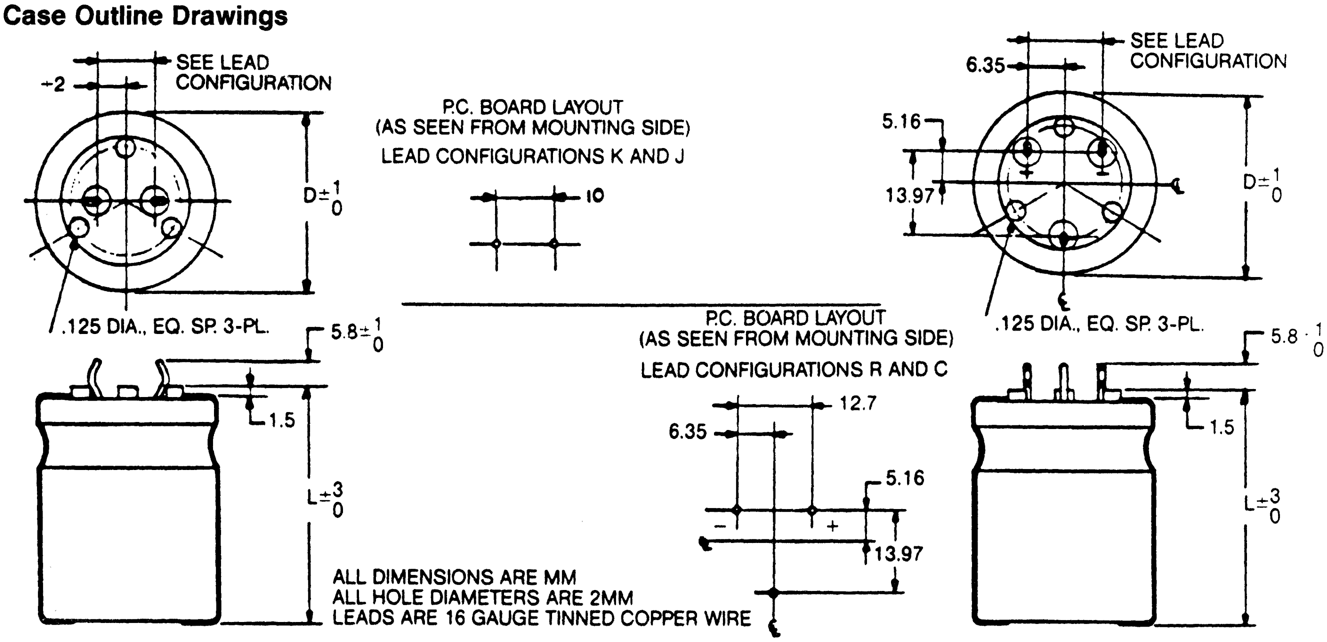
XXXX DE 102 M 200 E F

- **XXXX** — Philips Components Product Series
- **DE** — Case Size Code (See physical spec.)
- **102** — Capacitance: XX = Significant Digits, X = Multiplier, i.e. 102 = 1,000 μF
- **M** — Tolerance: M = ±20%
- **200** — Working Voltage
- **E** — Cover Construction: E = Two leads 10.0mm spacing. U = Three leads 12.7mm spacing. (See physical spec.) Supplied with Epoxy End Seal
- **F** — Standard Insulation: F = .006″ PVC

Insulated Case Dimensions

Case Codes	Dimensions (mm)		Dimensions (in.)	
	$D\pm^{1}_{0}$mm	$L\pm^{2}_{0}$mm	$D\pm^{.039}_{0}$	$L\pm^{.118}_{0}$
BD	25	35	.984	1.378
BE	25	40	.984	1.575
BF	25	50	.984	1.969
CC	30	30	1.181	1.181
CD	30	35	1.181	1.378
CE	30	40	1.181	1.575
CF	30	50	1.181	1.969
CG	30	63	1.181	2.480
CH	30	80	1.181	3.150
DC	35	30	1.378	1.181
DD	35	35	1.378	1.378
DE	35	40	1.378	1.575
DF	35	50	1.378	1.969
DG	35	63	1.378	2.480
DH	35	80	1.378	3.150

Case Outline Drawings



6.3 VDC Working, 9 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
18000	3487BD183M6P3EF	25*35	.0410	3.75
22000	3487BE223M6P3EF	25*40	.0336	4.35
33000	3487BF333M6P3EF	25*50	.0246	5.55
18000	3487CC183M6P3EF	30*30	.0538	3.49
27000	3487CD273M6P3EF	30*35	.0409	4.22
33000	3487CE333M6P3EF	30*40	.0335	4.89
47000	3487CF473M6P3EF	30*50	.0250	6.15
68000	3487CG683M6P3EF	30*63	.0188	7.76
82000	3487CH823M6P3EF	30*80	.0154	9.47
27000	3487DC273M6P3EF	35*30	.0602	3.66
39000	3487DD393M6P3EF	35*35	.0457	4.42
47000	3487DE473M6P3EF	35*40	.0374	5.11
68000	3487DF683M6P3EF	35*50	.0278	6.42
100000	3487DG104M6P3EF	35*63	.0208	8.12
120000	3487DH124M6P3EF	35*80	.0169	9.89

10 VDC Working, 15 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
15000	3487BD153M010EF	25*35	.0409	3.75
18000	3487BE183M010EF	25*40	.0338	4.34
22000	3487BF223M010EF	25*50	.0263	5.37
15000	3487CC153M010EF	30*30	.0542	3.48
22000	3487CD223M010EF	30*35	.0413	4.20
27000	3487CE273M010EF	30*40	.0338	4.87
39000	3487CF393M010EF	30*50	.0252	6.13
56000	3487CG563M010EF	30*63	.0189	7.74
68000	3487CH683M010EF	30*80	.0155	9.44
22000	3487DC223M010EF	35*30	.0610	3.64
27000	3487DD273M010EF	35*35	.0469	4.36
39000	3487DE393M010EF	35*40	.0379	5.08
56000	3487DF563M010EF	35*50	.0281	6.39
68000	3487DG683M010EF	35*63	.0213	8.02
100000	3487DH104M010EF	35*80	.0170	9.86

16 VDC Working, 20 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
10000	3487BD103M016EF	25*35	.0420	3.70
12000	3487BE123M016EF	25*40	.0347	4.28
15000	3487BF153M016EF	25*50	.0268	5.32
10000	3487CC103M016EF	30*30	.0553	3.44
12000	3487CD123M016EF	30*35	.0428	4.12
18000	3487CE183M016EF	30*40	.0345	4.82
22000	3487CF223M016EF	30*50	.0260	6.03
33000	3487CG333M016EF	30*63	.0194	7.64
47000	3487CH473M016EF	30*80	.0157	9.38
15000	3487DC153M016EF	35*30	.0623	3.60
18000	3487DD183M016EF	35*35	.0479	4.31
22000	3487DE223M016EF	35*40	.0391	5.00
33000	3487DF333M016EF	35*50	.0289	6.30
47000	3487DG473M016EF	35*63	.0216	7.96
68000	3487DH683M016EF	35*80	.0173	9.78

25 VDC Working, 40 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
6800	3487BD682M025EF	25*35	.0501	3.39
8200	3487BE822M025EF	25*40	.0410	3.94
12000	3487BF123M025EF	25*50	.0301	5.01
6800	3487CC682M025EF	30*30	.0724	3.01
10000	3487CD103M025EF	30*35	.0547	3.65
12000	3487CE123M025EF	30*40	.0447	4.23
18000	3487CF183M025EF	30*50	.0329	5.37
22000	3487CG223M025EF	30*63	.0246	6.79
33000	3487CH333M025EF	30*80	.0195	8.41
10000	3487DC103M025EF	35*30	.0859	3.06
15000	3487DD153M025EF	35*35	.0649	3.71
18000	3487DE183M025EF	35*40	.0528	4.30
22000	3487DF223M025EF	35*50	.0391	5.41
33000	3487DG333M025EF	35*63	.0286	6.91
47000	3487DH473M025EF	35*80	.0227	8.55

35 VDC Working, 50 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
4700	3487BD472M035EF	25*35	.0522	3.32
5600	3487BE562M035EF	25*40	.0427	3.86
8200	3487BF822M035EF	25*50	.0314	4.92
5600	3487CC562M035EF	30*30	.0731	2.99
6800	3487CD682M035EF	30*35	.0562	3.60
8200	3487CE822M035EF	30*40	.0459	4.18
12000	3487CF123M035EF	30*50	.0338	5.29
18000	3487CG183M035EF	30*63	.0249	6.75
22000	3487CH223M035EF	30*80	.0200	8.30
8200	3487DC822M035EF	35*30	.0867	3.05
10000	3487DD103M035EF	35*35	.0663	3.67
12000	3487DE123M035EF	35*40	.0539	4.26
18000	3487DF183M035EF	35*50	.0394	5.39
27000	3487DG273M035EF	35*63	.0288	6.89
33000	3487DH333M035EF	35*80	.0230	8.49

50 VDC Working, 75 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
3300	3487BD332M050EF	25*35	.0546	3.25
3900	3487BE392M050EF	25*40	.0448	3.77
5600	3487BF562M050EF	25*50	.0329	4.80
3300	3487CC332M050EF	30*30	.0769	2.92
4700	3487CD472M050EF	30*35	.0580	3.54
5600	3487CE562M050EF	30*40	.0475	4.10
8200	3487CF822M050EF	30*50	.0349	5.21
12000	3487CG123M050EF	30*63	.0257	6.65
15000	3487CH153M050EF	30*80	.0207	8.18
4700	3487DC472M050EF	35*30	.0897	3.00
6800	3487DD682M050EF	35*35	.0678	3.63
8200	3487DE822M050EF	35*40	.0551	4.21
12000	3487DF123M050EF	35*50	.0404	5.33
18000	3487DG183M050EF	35*63	.0294	6.82
22000	3487DH223M050EF	35*80	.0235	8.40

63 VDC Working, 90 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
2200	3487BD222M063EF	25*35	.0589	3.13
2700	3487BE272M063EF	25*40	.0480	3.64
3900	3487BF392M063EF	25*50	.0351	4.65
2200	3487CC222M063EF	30*30	.0813	2.84
3300	3487CD332M063EF	30*35	.0607	3.46
3900	3487CE392M063EF	30*40	.0497	4.01
5600	3487CF562M063EF	30*50	.0365	5.09
8200	3487CG822M063EF	30*63	.0267	6.52
10000	3487CH103M063EF	30*80	.0216	8.01
3300	3487DC332M063EF	35*30	.0925	2.95
4700	3487DD472M063EF	35*35	.0697	3.58
5600	3487DE562M063EF	35*40	.0568	4.15
8200	3487DF822M063EF	35*50	.0416	5.25
12000	3487DG123M063EF	35*63	.0304	6.71
15000	3487DH153M063EF	35*80	.0241	8.29

80 VDC Working, 100 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
1500	3487BD152M080EF	25*35	.1197	2.19
1800	3487BE182M080EF	25*40	.0988	2.54
2200	3487BF222M080EF	25*50	.0779	3.12
1500	3487CC152M080EF	30*30	.1401	2.16
2200	3487CD222M080EF	30*35	.1040	2.64
2700	3487CE272M080EF	30*40	.0844	3.08
3900	3487CF392M080EF	30*50	.0612	3.93
5600	3487CG562M080EF	30*63	.0443	5.06
6800	3487CH682M080EF	30*80	.0353	6.26
2200	3487DC222M080EF	35*30	.1430	2.37
2700	3487DD272M080EF	35*35	.1096	2.85
3900	3487DE392M080EF	35*40	.0867	3.36
5600	3487DF562M080EF	35*50	.0630	4.27
6800	3487DG682M080EF	35*63	.0467	5.41
10000	3487DH103M080EF	35*80	.0359	6.79

100 VDC Working, 150 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
1200	3487BD122M100EF	25*35	.1297	2.11
1500	3487BE152M100EF	25*40	.1046	2.47
2200	3487BF222M100EF	25*50	.0739	3.20
1200	3487CC122M100EF	30*30	.1481	2.10
1800	3487CD182M100EF	30*35	.1080	2.59
2200	3487CE222M100EF	30*40	.0878	3.02
3300	3487CF332M100EF	30*50	.0630	3.88
4700	3487CG472M100EF	30*63	.0456	4.99
5600	3487CH562M100EF	30*80	.0366	6.15
1800	3487DC182M100EF	35*30	.1471	2.34
2700	3487DD272M100EF	35*35	.1091	2.86
3300	3487DE332M100EF	35*40	.0885	3.32
4700	3487DF472M100EF	35*50	.0644	4.22
6800	3487DG682M100EF	35*63	.0465	5.42
8200	3487DH822M100EF	35*80	.0368	6.71

160 VDC Working, 200 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
560	3487BD561M160EF	25*35	.2338	1.57
680	3487BE681M160EF	25*40	.1921	1.82
1000	3487BF102M160EF	25*50	.1333	2.38
680	3487CC681M160EF	30*30	.2262	1.70
820	3487CD821M160EF	30*35	.1803	2.01
1000	3487CE102M160EF	30*40	.1472	2.33
1500	3487CF152M160EF	30*50	.1024	3.04
2200	3487CG222M160EF	30*63	.0722	3.97
2700	3487CH272M160EF	30*80	.0580	4.88
1000	3487DC102M160EF	35*30	.2035	1.99
1200	3487DD122M160EF	35*35	.1583	2.37
1500	3487DE152M160EF	35*40	.1275	2.77
2200	3487DF222M160EF	35*50	.0912	3.55
3300	3487DG332M160EF	35*63	.0645	4.61
3900	3487DH392M160EF	35*80	.0515	5.68

200 VDC Working, 250 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
470	3487BD471M200EF	25*35	.2386	1.55
560	3487BE561M200EF	25*40	.1988	1.79
820	3487BF821M200EF	25*50	.1384	2.34
470	3487CC471M200EF	30*30	.2597	1.59
680	3487CD681M200EF	30*35	.1866	1.97
820	3487CE821M200EF	30*40	.1533	2.28
1200	3487CF122M200EF	30*50	.1080	2.96
1800	3487CG182M200EF	30*63	.0752	3.89
2200	3487CH222M200EF	30*80	.0606	4.78
680	3487DC681M200EF	35*30	.2254	1.89
1000	3487DD102M200EF	35*35	.1644	2.33
1200	3487DE122M200EF	35*40	.1342	2.70
1800	3487DF182M200EF	35*50	.0950	3.47
2200	3487DG222M200EF	35*63	.0717	4.37
3300	3487DH332M200EF	35*80	.0531	5.59

250 VDC Working, 300 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
330	3487BD331M250EF	25*35	.2824	1.43
390	3487BE391M250EF	25*40	.2374	1.64
560	3487BF561M250EF	25*50	.1673	2.13
390	3487CC391M250EF	30*30	.2717	1.55
470	3487CD471M250EF	30*35	.2181	1.82
680	3487CE681M250EF	30*40	.1605	2.23
820	3487CF821M250EF	30*50	.1268	2.73
1200	3487CG122M250EF	30*63	.0889	3.57
1800	3487CH182M250EF	30*80	.0637	4.66
560	3487DC561M250EF	35*30	.2378	1.84
680	3487DD681M250EF	35*35	.1866	2.18
820	3487DE821M250EF	35*40	.1526	2.53
1200	3487DF122M250EF	35*50	.1082	3.26
1800	3487DG182M250EF	35*63	.0757	4.25
2200	3487DH222M250EF	35*80	.0603	5.24

300 VDC Working, 350 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
180	3487BD181M300EF	25*35	.9048	.799
220	3487BE221M300EF	25*40	.7403	.929
330	3487BF331M300EF	25*50	.4965	1.23
220	3487CC221M300EF	30*30	.7691	.924
270	3487CD271M300EF	30*35	.6219	1.08
330	3487CE331M300EF	30*40	.5085	1.25
470	3487CF471M300EF	30*50	.3590	1.62
680	3487CG681M300EF	30*63	.2500	2.13
820	3487CH821M300EF	30*80	.2065	2.59
270	3487DC271M300EF	35*30	.6457	1.11
390	3487DD391M300EF	35*35	.4550	1.40
470	3487DE471M300EF	35*40	.3757	1.61
680	3487DF681M300EF	35*50	.2627	2.09
1000	3487DG102M300EF	35*63	.1812	2.75
1200	3487DH122M300EF	35*80	.1492	3.33

400 VDC Working, 450 VDC Surge

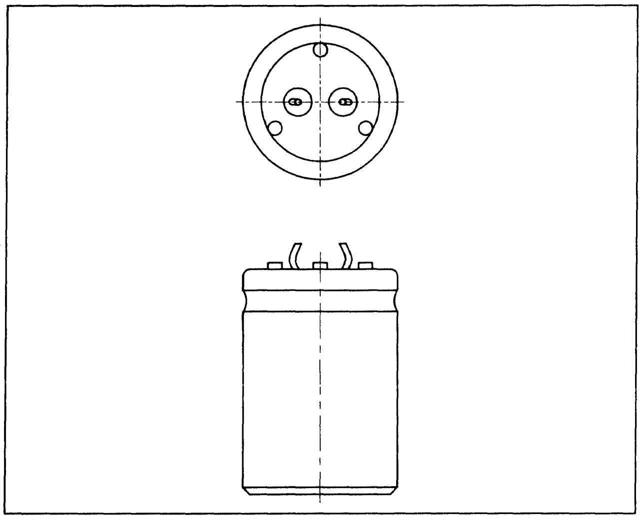
Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
120	3487BD121M400EF	25*35	1.049	.742
150	3487BE151M400EF	25*40	.8401	.872
220	3487BF221M400EF	25*50	.5752	1.14
120	3487CC121M400EF	30*30	1.065	.785
180	3487CD181M400EF	30*35	.7183	1.00
220	3487CE221M400EF	30*40	.5874	1.16
330	3487CF331M400EF	30*50	.3955	1.54
470	3487CG471M400EF	30*63	.2791	2.02
560	3487CH561M400EF	30*80	.2331	2.43
180	3487DC181M400EF	35*30	.7424	1.04
270	3487DD271M400EF	35*35	.5062	1.32
330	3487DE331M400EF	35*40	.4132	1.53
470	3487DF471M400EF	35*50	.2923	1.98
680	3487DG681M400EF	35*63	.2041	2.59
820	3487DH821M400EF	35*80	.1675	3.14

350 VDC Working, 400 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
150	3487BD151M350EF	25*35	.9492	.780
180	3487BE181M350EF	25*40	.7904	.899
270	3487BF271M350EF	25*50	.5299	1.19
150	3487CC151M350EF	30*30	.9659	.824
220	3487CD221M350EF	30*35	.6652	1.04
270	3487CE271M350EF	30*40	.5419	1.21
390	3487CF391M350EF	30*50	.3777	1.58
560	3487CG561M350EF	30*63	.2647	2.07
680	3487CH681M350EF	30*80	.2173	2.52
220	3487DC221M350EF	35*30	.6892	1.08
330	3487DD331M350EF	35*35	.4705	1.37
390	3487DE391M350EF	35*40	.3947	1.57
560	3487DF561M350EF	35*50	.2775	2.03
820	3487DG821M350EF	35*63	.1920	2.67
1000	3487DH102M350EF	35*80	.1561	3.26

450 VDC Working, 500 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
82	3487BD820M450EF	25*35	1.041	.744
120	3487BE121M450EF	25*40	.7180	.943
150	3487BF151M450EF	25*50	.5723	1.15
100	3487CC101M450EF	30*30	.8812	.863
120	3487CD121M450EF	30*35	.7285	1.00
150	3487CE151M450EF	30*40	.5836	1.17
220	3487CF221M450EF	30*50	.4008	1.53
330	3487CG331M450EF	30*63	.2700	2.05
470	3487CH471M450EF	30*80	.1925	2.68
150	3487DC151M450EF	35*30	.6237	1.13
180	3487DD181M450EF	35*35	.5105	1.32
220	3487DE221M450EF	35*40	.4170	1.53
330	3487DF331M450EF	35*50	.2828	2.01
470	3487DG471M450EF	35*63	.1999	2.61
560	3487DH561M450EF	35*80	.1658	3.16



Industrial/Computer Grade Snap-In Aluminum Electrolytic Capacitors

Description

The Series 3488 utilizes a snap-in terminal configuration. This allows fast and easy mounting onto printed circuit boards, eliminating the need for mounting hardware and reducing assembly time.

A newly designed safety vent is integrated into the top of the case, opposite from the terminal end. The possibility of printed circuit board spoilage is thereby reduced.

A plastic coating of the terminal header provides excellent resistance to the entrance of most normally used printed circuit board cleaners.

All connections of the 3488 are welded to insure long-term electrical integrity.

Features

Electrical

- Capacitance from 220 to 120,000 μF.
- Voltage range from 6.3 WVDC to 250 WVDC.
- 85°C ambient operating temperature.
- 2,000-hour life at 105°C with rated DC voltage applied.
- Standard capacitance tolerance ±20%.
- Excellent frequency response.

Mechanical

- Snap-in (self-mounting) terminals.
- All welded construction.
- Venting mechanism at the top of the case for better printed circuit board protection.
- Pitchless construction (no potting compound).
- Protective plastic end seal to allow on-board cleaning.
- Integral stand off feet on terminal cover for ease of board cleaning.

Performance Characteristics: See page 95
Life Prediction Guidelines: See page 99
Application Guidelines: See page 105

How to Specify

Philips Components Series Capacitors can be completely specified using the following designation:

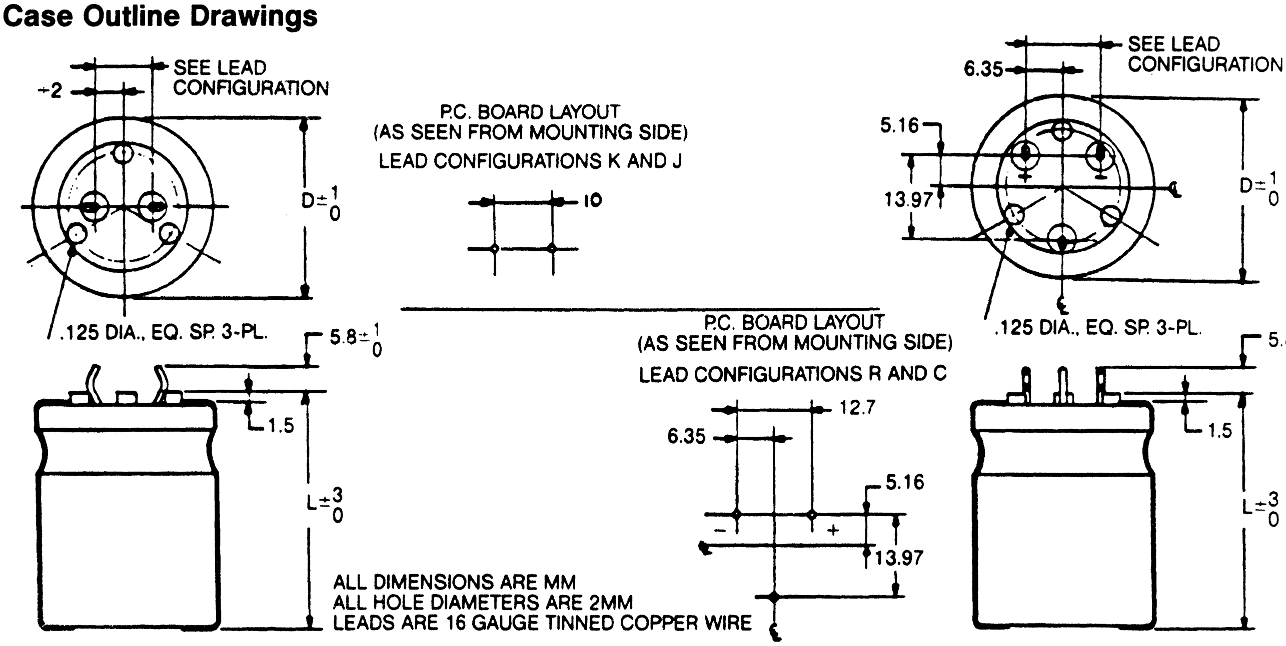
XXXX DE 102 M 200 E F

- **XXXX** — Philips Components Product Series
- **DE** — Case Size Code (See physical spec.)
- **102** — Capacitance: XX = Significant Digits, X = Multiplier, i.e. 102 = 1,000 μF
- **M** — Tolerance: M = ±20%
- **200** — Working Voltage
- **E** — Cover Construction: E = Two leads 10.0mm spacing. U = Three leads 12.7mm spacing. (See physical spec.) Supplied with Epoxy End Seal
- **F** — Standard Insulation: F = .006″ PVC

Insulated Case Dimensions

Case Codes	Dimensions (mm)		Dimensions (in.)	
	$D\pm^{1}_{0}$mm	$L\pm^{2}_{0}$mm	$D\pm^{.039}_{0}$	$L\pm^{.118}_{0}$
BD	25	35	.984	1.378
BE	25	40	.984	1.575
BF	25	50	.984	1.969
CC	30	30	1.181	1.181
CD	30	35	1.181	1.378
CE	30	40	1.181	1.575
CF	30	50	1.181	1.969
CG	30	63	1.181	2.480
CH	30	80	1.181	3.150
DC	35	30	1.378	1.181
DD	35	35	1.378	1.378
DE	35	40	1.378	1.575
DF	35	50	1.378	1.969
DG	35	63	1.378	2.480
DH	35	80	1.378	3.150

Case Outline Drawings



Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

6.3 VDC Working, 9 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
18000	3488BD183M6P3EF	25*35	.0404	5.34
22000	3488BE223M6P3EF	25*40	.0332	6.20
27000	3488BF273M6P3EF	25*50	.0257	7.68
18000	3488CC183M6P3EF	30*30	.0313	6.47
22000	3488CD223M6P3EF	30*35	.0251	7.62
33000	3488CE333M6P3EF	30*40	.0185	9.29
47000	3488CF473M6P3EF	30*50	.0137	11.7
56000	3488CG563M6P3EF	30*63	.0112	14.2
82000	3488CH823M6P3EF	30*80	.0086	17.8
27000	3488DC273M6P3EF	35*30	.0265	7.80
33000	3488DD333M6P3EF	35*35	.0209	9.25
47000	3488DE473M6P3EF	35*40	.0165	10.8
56000	3488DF563M6P3EF	35*50	.0129	13.3
82000	3488DG823M6P3EF	35*63	.0095	16.9
120000	3488DH124M6P3EF	35*80	.0076	20.8

10 VDC Working, 15 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
12000	3488BD123M010EF	25*35	.0422	5.23
15000	3488BE153M010EF	25*40	.0344	6.09
22000	3488BF223M010EF	25*50	.0253	7.74
12000	3488CC123M010EF	30*30	.0336	6.25
18000	3488CD183M010EF	30*35	.0240	7.79
22000	3488CE223M010EF	30*40	.0198	8.98
33000	3488CF333M010EF	30*50	.0142	11.5
47000	3488CG473M010EF	30*63	.0107	14.5
56000	3488CH563M010EF	30*80	.0090	17.4
18000	3488DC183M010EF	35*30	.0277	7.63
27000	3488DD273M010EF	35*35	.0206	9.31
33000	3488DE333M010EF	35*40	.0169	10.7
47000	3488DF473M010EF	35*50	.0126	13.5
68000	3488DG683M010EF	35*63	.0094	17.0
82000	3488DH823M010EF	35*80	.0078	20.5

16 VDC Working, 20 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
8200	3488BD822M016EF	25*35	.0495	4.82
10000	3488BE103M016EF	25*40	.0405	5.61
15000	3488BF153M016EF	25*50	.0297	7.14
10000	3488CC103M016EF	30*30	.0341	6.20
12000	3488CD123M016EF	30*35	.0271	7.33
15000	3488CE153M016EF	30*40	.0221	8.52
22000	3488CF223M016EF	30*50	.0160	10.8
33000	3488CG333M016EF	30*63	.0117	13.9
39000	3488CH393M016EF	30*80	.0097	16.8
12000	3488DC123M016EF	35*30	.0330	7.00
18000	3488DD183M016EF	35*35	.0249	8.46
22000	3488DE223M016EF	35*40	.0204	9.80
33000	3488DF333M016EF	35*50	.0150	12.3
47000	3488DG473M016EF	35*63	.0112	15.6
56000	3488DH563M016EF	35*80	.0090	19.1

25 VDC Working, 40 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
5600	3488BD562M025EF	25*35	.0512	4.75
6800	3488BE682M025EF	25*40	.0418	5.52
10000	3488BF103M025EF	25*50	.0307	7.03
5600	3488CC562M025EF	30*30	.0383	5.85
8200	3488CD822M025EF	30*35	.0279	7.22
10000	3488CE103M025EF	30*40	.0230	8.35
15000	3488CF153M025EF	30*50	.0165	10.7
22000	3488CG223M025EF	30*63	.0121	13.7
27000	3488CH273M025EF	30*80	.0099	16.6
8200	3488DC822M025EF	35*30	.0341	6.88
12000	3488DD123M025EF	35*35	.0257	8.33
15000	3488DE153M025EF	35*40	.0210	9.65
22000	3488DF223M025EF	35*50	.0154	12.2
27000	3488DG273M025EF	35*63	.0117	15.3
39000	3488DH393M025EF	35*80	.0092	18.9

35 VDC Working, 50 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
3900	3488BD392M035EF	25*35	.0535	4.64
5600	3488BE562M035EF	25*40	.0426	5.47
6800	3488BF682M035EF	25*50	.0321	6.88
4700	3488CC472M035EF	30*30	.0380	5.87
5600	3488CD562M035EF	30*35	.0306	6.90
8200	3488CE822M035EF	30*40	.0231	8.33
10000	3488CF103M035EF	30*50	.0181	10.2
15000	3488CG153M035EF	30*63	.0131	13.1
22000	3488CH223M035EF	30*80	.0101	16.5
6800	3488DC682M035EF	35*30	.0347	6.82
8200	3488DD822M035EF	35*35	.0269	8.14
10000	3488DE103M035EF	35*40	.0220	9.43
15000	3488DF153M035EF	35*50	.0161	11.9
22000	3488DG223M035EF	35*63	.0119	15.1
27000	3488DH273M035EF	35*80	.0096	18.5

50 VDC Working, 75 VDC Surge

Capacitance (μF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
2200	3488BD222M050EF	25*35	.0591	4.41
3300	3488BE332M050EF	25*40	.0460	5.26
3900	3488BF392M050EF	25*50	.0352	6.57
2700	3488CC272M050EF	30*30	.0428	5.54
3900	3488CD392M050EF	30*35	.0313	6.83
4700	3488CE472M050EF	30*40	.0258	7.88
6800	3488CF682M050EF	30*50	.0187	10.0
8200	3488CG822M050EF	30*63	.0149	12.3
12000	3488CH123M050EF	30*80	.0113	15.6
3900	3488DC392M050EF	35*30	.0378	6.53
5600	3488DD562M050EF	35*35	.0283	7.94
6800	3488DE682M050EF	35*40	.0232	9.18
8200	3488DF822M050EF	35*50	.0177	11.3
12000	3488DG123M050EF	35*63	.0130	14.5
18000	3488DH183M050EF	35*80	.0102	18.0

63 VDC Working, 90 VDC Surge

Capacitance (µF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
1800	3488BD182M063EF	25*35	.0618	4.32
2200	3488BE222M063EF	25*40	.0505	5.03
2700	3488BF272M063EF	25*50	.0385	6.27
1800	3488CC182M063EF	30*30	.0486	5.19
2700	3488CD272M063EF	30*35	.0346	6.49
3300	3488CE332M063EF	30*40	.0283	7.52
4700	3488CF472M063EF	30*50	.0207	9.57
6800	3488CG682M063EF	30*63	.0150	12.3
8200	3488CH822M063EF	30*80	.0125	14.8
2700	3488DC272M063EF	35*30	.0412	6.26
3900	3488DD392M063EF	35*35	.0307	7.63
4700	3488DE472M063EF	35*40	.0251	8.82
6800	3488DF682M063EF	35*50	.0183	11.1
8200	3488DG822M063EF	35*63	.0141	13.9
12000	3488DH123M063EF	35*80	.0110	17.3

80 VDC Working, 100 VDC Surge

Capacitance (µF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
1200	3488BD122M080EF	25*35	.1313	2.96
1500	3488BE152M080EF	25*40	.1058	3.47
2200	3488BF222M080EF	25*50	.0747	4.51
1500	3488CC152M080EF	30*30	.0984	3.65
1800	3488CD182M080EF	30*35	.0803	4.26
2200	3488CE222M080EF	30*40	.0658	4.93
3300	3488CF332M080EF	30*50	.0453	6.47
4700	3488CG472M080EF	30*63	.0326	8.35
5600	3488CH562M080EF	30*80	.0272	10.0
1800	3488DC182M080EF	35*30	.0870	4.31
2700	3488DD272M080EF	35*35	.0614	5.39
3300	3488DE332M080EF	35*40	.0501	6.24
4700	3488DF472M080EF	35*50	.0361	7.97
6800	3488DG682M080EF	35*63	.0259	10.2
8200	3488DH822M080EF	35*80	.0212	12.5

100 VDC Working, 150 VDC Surge

Capacitance (µF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
820	3488BD821M100EF	25*35	.1421	2.85
1000	3488BE102M100EF	25*40	.1162	3.31
1200	3488BF122M100EF	25*50	.0933	4.03
820	3488CC821M100EF	30*30	.1264	3.22
1200	3488CD122M100EF	30*35	.0885	4.06
1500	3488CE152M100EF	30*40	.0713	4.74
1800	3488CF182M100EF	30*50	.0582	5.70
2700	3488CG272M100EF	30*63	.0399	7.54
3900	3488CH392M100EF	30*80	.0288	9.80
1200	3488DC122M100EF	35*30	.0957	4.11
1500	3488DD152M100EF	35*35	.0754	4.87
2200	3488DE222M100EF	35*40	.0550	5.96
2700	3488DF272M100EF	35*50	.0433	7.28
3900	3488DG392M100EF	35*63	.0309	9.42
5600	3488DH562M100EF	35*80	.0228	12.0

160 VDC Working, 200 VDC Surge

Capacitance (µF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
470	3488BD471M160EF	25*35	.2489	2.15
680	3488BE681M160EF	25*40	.1789	2.67
820	3488BF821M160EF	25*50	.1444	3.24
560	3488CC561M160EF	30*30	.2003	2.56
680	3488CD681M160EF	30*35	.1635	2.98
1000	3488CE102M160EF	30*40	.1142	3.75
1200	3488CF122M160EF	30*50	.0937	4.50
1800	3488CG182M160EF	30*63	.0637	5.97
2700	3488CH272M160EF	30*80	.0440	7.93
820	3488DC821M160EF	35*30	.1474	3.31
1000	3488DD102M160EF	35*35	.1187	3.88
1200	3488DE122M160EF	35*40	.0984	4.46
1800	3488DF182M160EF	35*50	.0673	5.84
2700	3488DG272M160EF	35*63	.0462	7.70
3300	3488DH332M160EF	35*80	.0376	9.39

200 VDC Working, 250 VDC Surge

Capacitance (µF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
330	3488BD331M200EF	25*35	.2824	2.02
390	3488BE391M200EF	25*40	.2374	2.31
560	3488BF561M200EF	25*50	.1673	3.01
390	3488CC391M200EF	30*30	.2298	2.39
470	3488CD471M200EF	30*35	.1890	2.77
680	3488CE681M200EF	30*40	.1334	3.47
820	3488CF821M200EF	30*50	.1092	4.16
1200	3488CG122M200EF	30*63	.0756	5.48
1800	3488CH182M200EF	30*80	.0520	7.30
560	3488DC561M200EF	35*30	.1704	3.08
680	3488DD681M200EF	35*35	.1380	3.60
820	3488DE821M200EF	35*40	.1141	4.14
1200	3488DF122M200EF	35*50	.0793	5.38
1800	3488DG182M200EF	35*63	.0542	7.11
2200	3488DH222M200EF	35*80	.0442	8.66

250 VDC Working, 300 VDC Surge

Capacitance (µF)	Philips Part Number	Case Size	Max. ESR (ohm) 120Hz +25C	Max. Ripple (amp) 20Hz +85C
220	3488BD221M250EF	25*35	.2922	1.98
270	3488BE271M250EF	25*40	.2381	2.31
390	3488BF391M250EF	25*50	.1670	3.01
270	3488CC271M250EF	30*30	.2303	2.38
330	3488CD331M250EF	30*35	.1871	2.79
390	3488CE391M250EF	30*40	.1578	3.19
560	3488CF561M250EF	30*50	.1108	4.13
820	3488CG821M250EF	30*63	.0766	5.45
1200	3488CH122M250EF	30*80	.0538	7.18
390	3488DC391M250EF	35*30	.1703	3.08
470	3488DD471M250EF	35*35	.1387	3.59
560	3488DE561M250EF	35*40	.1158	4.11
820	3488DF821M250EF	35*50	.0804	5.34
1200	3488DG122M250EF	35*63	.0560	6.99
1500	3488DH152M250EF	35*80	.0449	8.59

NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Large types, minimized dimensions, cylindrical aluminium case, insulated with a blue sleeve
- Safety vent in the bottom of the aluminium case
- Charge and discharge proof
- Long useful life: 10 000 hours/85 °C
- High ripple current capability.

APPLICATIONS

- General purpose, industrial and audio/video systems
- Smoothing and filtering
- Standard and switched mode power supplies
- Energy storage in pulse systems.

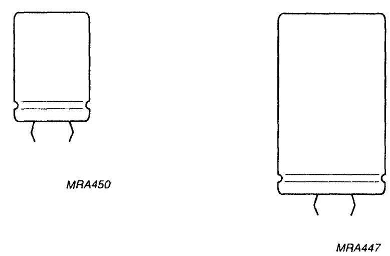


Fig.1 Component outlines.

QUICK REFERENCE DATA

	056
Case size (∅D_{nom} x L_{nom} in mm)	22 x 25 to 35 x 50
Rated capacitance range (E6/E12 series), C_R	470 to 68 000 µF
Tolerance on C_R	±20%
Rated voltage range, U_R	10 V to 100 V
Category temperature range	–40 to +85 °C
Endurance test at 85 °C	5000 hours
Useful life at 85 °C	10 000 hours
Useful life at U_R, 40 °C and 1.4 x I_R applied	175 000 hours
Shelf life at 0 V, 85 °C	500 hours
Basic specifications	IEC 384-4-1, CECC 30 301, LL grade
Climatic category IEC 68 DIN 40040	 40/085/56 GPF

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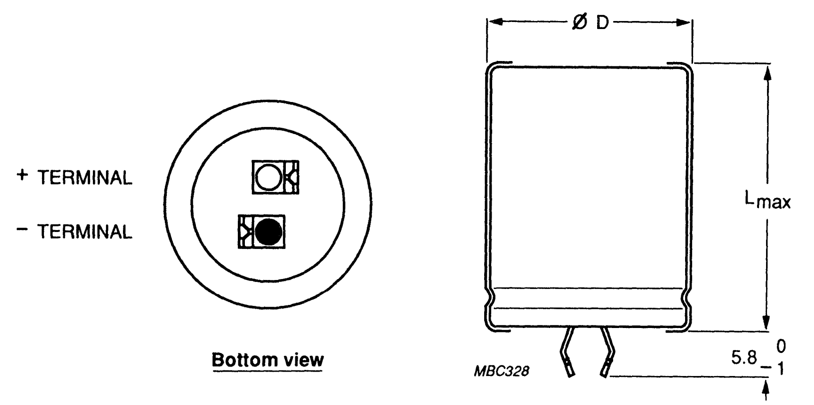
Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (**∅D x L** in **mm)** for 056 series

C_R (μF)	U_R (V)							
	10	**16**	**25**	**35**	**40**	**50**	**63**	**100**
470								22 x 25
680								22 x 30
1000							22 x 25	25 x 30 22 x 40
1500						22 x 25	22 x 30	30 x 30 25 x 40
2200				22 x 25	22 x 25	22 x 30	25 x 30 22 x 40	30 x 40 25 x 50
3300			22 x 25	22 x 30	22 x 30	25 x 30 22 x 40	30 x 30 25 x 40	35 x 40 30 x 50
4700		22 x 25	22 x 30	25 x 30 22 x 40	25 x 30 22 x 40	30 x 30 25 x 40	30 x 40 25 x 50	35 x 50
6800	22 x 25	22 x 30	25 x 30 22 x 40	30 x 30 25 x 40	30 x 30 25 x 40	30 x 40 25 x 50	35 x 40 30 x 50	
10 000	22 x 30	25 x 30 22 x 40	30 x 30 25 x 40	30 x 40 25 x 50	30 x 40 25 x 50	35 x 40 30 x 50	35 x 50	
15 000	25 x 30 22 x 40	30 x 30 25 x 40	30 x 40 25 x 50	35 x 40 30 x 50	35 x 40 30 x 50	35 x 50		
22 000	30 x 30 25 x 40	30 x 40 25 x 50	35 x 40 30 x 50	35 x 50	35 x 50			
33 000	30 x 40 25 x 50	35 x 40 30 x 50	35 x 50					
47 000	35 x 40 30 x 50	35 x 50						
68 000	35 x 50							

MECHANICAL DATA and PACKING QUANTITIES

Dimensions in mm.



The minus terminal can be marked with a black dot or with an imprinted minus sign.

Fig.2 Snap-in.

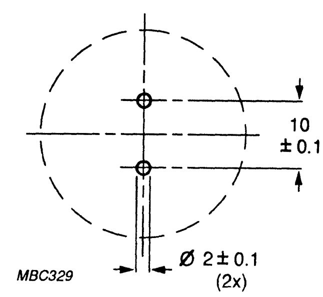


Fig.3 Piercing diagram.

Table 3 Dimensions in mm; mass in g

CASE SIZE $ØD_{nom}$ x L_{nom}	CASE CODE	$ØD_{max}$	L_{max}	APPROX. MASS	PACKING QUANTITIES (units per box)
22 x 25	2225	23	27	12	100
22 x 30	2230	23	32	16	100
22 x 35	2235	23	37	20	100
22 x 40	2240	23	42	23	100
25 x 30	2530	26.5	32	22	100
25 x 35	2535	26.5	37	24	100
25 x 40	2540	26.5	42	27	100
25 x 45	2545	26.5	47	32	100
25 x 50	2550	26.5	52	38	100
30 x 30	3030	31.5	32	30	100
30 x 35	3035	31.5	37	35	100
30 x 40	3040	31.5	42	40	100
30 x 45	3045	31.5	47	45	100
30 x 50	3050	31.5	52	50	100
35 x 30	3530	36.5	32	40	50
35 x 35	3535	36.5	37	48	50
35 x 40	3540	36.5	42	55	50
35 x 45	3545	36.5	47	63	50
35 x 50	3550	36.5	52	72	50

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Tables 4 and 5 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

- C_R = rated capacitance at 100 Hz
- I_R = rated RMS ripple current at 100 Hz, 85 °C
- I_{L1} = max. leakage current after 1 minute at U_R
- I_{L5} = max. leakage current after 5 minutes at U_R
- ESR = max. equivalent series resistance at 100 Hz
- Z = max. impedance at 10 kHz.

Ordering Example

Electrolytic capacitors
PSM-SI 056/057

10 000 μF/25 V, ±20%

Case size 25 x 40 mm

Catalogue number:
2222 056 46103.

Table 4 Electrical data and ordering information for 056 series

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅D x L (mm)	CASE CODE	I_R 100 Hz 85 °C (A)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	CATALOGUE NUMBER 2222 . . . .
10	6800	22 x 25	2225	2.04	412	140	76	62	056 54682
	10 000	22 x 30	2230	2.56	608	205	56	45	056 54103
	15 000	25 x 30	2530	3.12	904	304	44	39	056 54153
	15 000	22 x 40	2240	3.39	904	304	41	34	056 44153
	22 000	30 x 30	3030	3.47	1324	444	44	37	056 54223
	22 000	25 x 40	2540	4.12	1324	444	34	28	056 44223
	33 000	30 x 40	3040	4.58	1984	664	32	28	056 54333
	33 000	25 x 50	2550	4.70	1984	664	30	27	056 44333
	47 000	35 x 40	3540	5.10	2824	944	31	26	056 54473
	47 000	30 x 50	3050	5.39	2824	944	28	24	056 44473
	68 000	35 x 50	3550	5.88	4084	1364	28	23	056 54683
16	4700	22 x 25	2225	2.01	455	154	79	62	056 55472
	6800	22 x 30	2230	2.54	657	222	57	45	056 55682
	10 000	25 x 30	2530	3.02	964	324	47	39	056 55103
	10 000	22 x 40	2240	3.28	964	324	44	34	056 45103
	15 000	30 x 30	3030	3.36	1444	484	47	37	056 55153
	15 000	25 x 40	2540	4.00	1444	484	34	28	056 45153
	22 000	30 x 40	3040	4.51	2116	708	33	28	056 55223
	22 000	25 x 50	2550	3.97	2116	708	42	41	056 45223
	33 000	35 x 40	3540	5.02	3172	1060	32	28	056 55333
	33 000	30 x 50	3050	4.75	3172	1060	36	34	056 45333
	47 000	35 x 50	3550	5.34	4516	1508	34	32	056 55473

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅D x L (mm)	CASE CODE	I_R 100 Hz 85 °C (A)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	CATALOGUE NUMBER 2222 . . . .
25	3300	22 x 25	2225	1.88	499	169	89	61	056 56332
	4700	22 x 30	2230	2.37	709	239	65	45	056 56472
	6800	25 x 30	2530	2.81	1024	344	54	41	056 56682
	6800	22 x 40	2240	3.16	1024	344	47	38	056 46682
	10 000	30 x 30	3030	3.25	1504	504	50	38	056 56103
	10 000	25 x 40	2540	3.73	1504	504	39	30	056 46103
	15 000	30 x 40	3040	4.73	2254	754	30	28	056 56153
	15 000	25 x 50	2550	3.92	2254	754	43	39	056 46153
	22 000	35 x 40	3540	4.48	3304	1104	40	28	056 56223
	22 000	30 x 50	3050	4.96	3304	1104	36	23	056 46223
	33 000	35 x 50	3550	4.98	4954	1654	39	33	056 56333
35	2200	22 x 25	2225	1.85	466	158	92	61	056 50222
	3300	22 x 30	2230	2.09	697	235	67	44	056 50332
	4700	25 x 30	2530	2.66	991	333	60	40	056 50472
	4700	22 x 40	2240	3.10	991	333	49	38	056 40472
	6800	30 x 30	3030	3.16	1432	480	53	38	056 50682
	6800	25 x 40	2540	3.44	1432	480	46	30	056 40682
	10 000	30 x 40	3040	4.20	2104	704	38	28	056 50103
	10 000	25 x 50	2550	4.41	2104	704	34	28	056 40103
	15 000	35 x 40	3540	4.32	3154	1054	43	28	056 50153
	15 000	30 x 50	3050	4.75	3154	1054	36	26	056 40153
	22 000	35 x 50	3550	5.33	4624	1544	34	24	056 50223
40	2200	22 x 25	2225	1.85	532	180	92	61	056 57222
	3300	22 x 30	2230	2.09	796	260	67	45	056 57332
	4700	25 x 30	2530	2.28	1132	380	82	70	056 57472
	4700	22 x 40	2240	3.10	1132	380	49	38	056 47472
	6800	30 x 30	3030	3.16	1636	348	53	38	056 57682
	6800	25 x 40	2540	3.06	1636	548	58	50	056 47682
	10 000	30 x 40	3040	4.20	2404	804	38	28	056 57103
	10 000	25 x 50	2550	3.88	2404	804	44	39	056 47103
	15 000	35 x 40	3540	4.05	3604	1204	49	41	056 57153
	15 000	30 x 50	3050	4.45	3604	1204	41	34	056 47153
	22 000	35 x 50	3550	4.86	5284	1764	40	33	056 57223

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅D x L (mm)	CASE CODE	I_R 100 Hz 85 °C (A)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	CATALOGUE NUMBER 2222 . . . .
50	1500	22 x 25	2225	1.36	454	154	170	130	056 51152
	2200	22 x 30	2230	1.75	664	124	120	91	056 51222
	3300	25 x 30	2530	2.17	994	334	90	72	056 51332
	3300	22 x 40	2240	2.42	994	334	80	63	056 41332
	4700	30 x 30	3030	2.65	1414	474	75	63	056 51472
	4700	25 x 40	2540	2.89	1414	474	65	52	056 41472
	6800	30 x 40	3040	3.56	2044	684	53	45	056 51682
	6800	25 x 50	2550	3.75	2044	684	50	43	056 41682
	10 000	35 x 40	3540	4.05	3004	1004	49	42	056 51103
	10 000	30 x 50	3050	4.50	3004	1004	40	35	056 41103
	15 000	35 x 50	3550	4.98	4504	1504	39	33	056 51153
63	1000	22 x 25	2225	1.46	382	130	148	104	056 58102
	1500	22 x 30	2230	1.87	571	193	105	72	056 58152
	2200	25 x 30	2530	2.32	836	281	79	59	056 58222
	2200	22 x 40	2240	2.54	836	281	73	53	056 48222
	3300	30 x 30	3030	2.87	1251	420	64	50	056 58332
	3300	25 x 40	2540	3.14	1251	420	55	44	056 48332
	4700	30 x 40	3040	3.67	1780	596	50	38	056 58472
	4700	25 x 50	2550	3.71	1780	596	48	38	056 48472
	6800	35 x 40	3540	4.33	2574	861	43	38	056 58682
	6800	30 x 50	3050	4.75	2574	861	42	37	056 48682
	10 000	35 x 50	3550	5.26	3784	1264	35	30	056 58103
100	470	22 x 25	2225	0.77	286	98	535	470	056 59471
	680	22 x 30	2230	0.99	412	160	375	328	056 59681
	1000	25 x 30	2530	1.27	604	204	265	235	056 59102
	1000	22 x 40	2240	1.35	604	204	260	225	056 49102
	1500	30 x 30	3030	1.67	904	304	190	170	056 59152
	1500	25 x 40	2540	1.75	904	304	180	160	056 49152
	2200	30 x 40	3040	2.27	1324	444	130	120	056 59222
	2200	25 x 50	2550	2.30	1324	444	125	110	056 49222
	3300	35 x 40	3540	2.84	1984	664	100	95	056 59332
	3300	30 x 50	3050	2.97	1984	664	92	85	056 49332
	4700	35 x 50	3550	3.59	2024	677	75	70	056 59472

Voltage

Surge voltage for short periods ≤100 V versions	$U_s = 1.15 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$

Equivalent series inductance (ESL)

Typical ESL for all case sizes	19 nH
Maximum ESL for all case sizes	25 nH

MARKING

- Rated capacitance
- Tolerance code on rated capacitance (M for ±20%)
- Rated voltage
- Climatic category (in accordance with IEC 68)
- Date code (year and week) in accordance with IEC 62
- Code for factory of origin
- Name of manufacturer
- '–' sign to indicate the negative terminal, visible from the top and side of the capacitor
- Code number (last 8 digits)
- Code for basic specification (in accordance with IEC 384-4-1, CECC 30 301).

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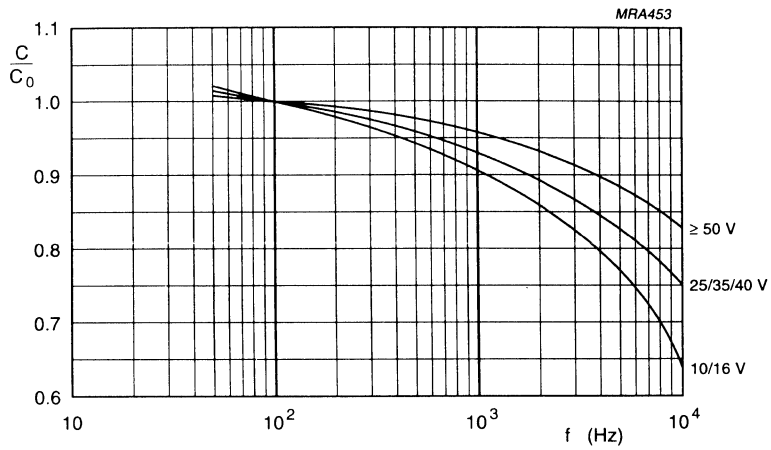
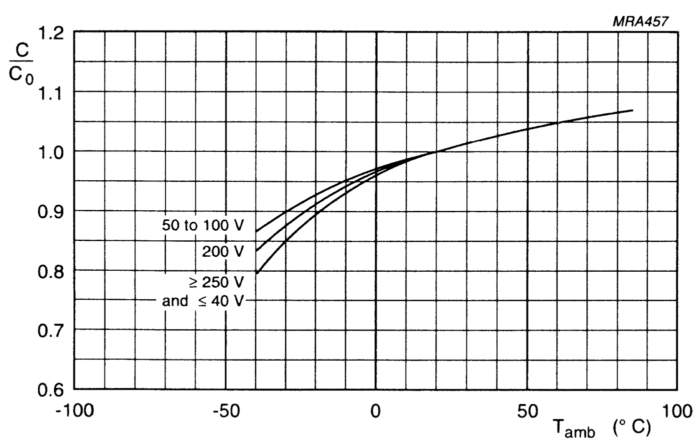
Capacitance (C)



C/C_0 = capacitance at 20 °C and 100 Hz.

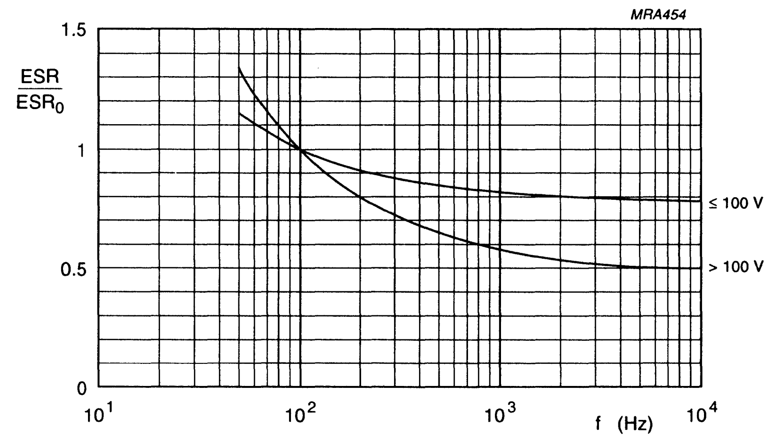
Fig.4 Multiplier of typical capacitance (C/C_0) as a function of frequency.



C/C_0 = capacitance at 20 °C and 100 Hz.

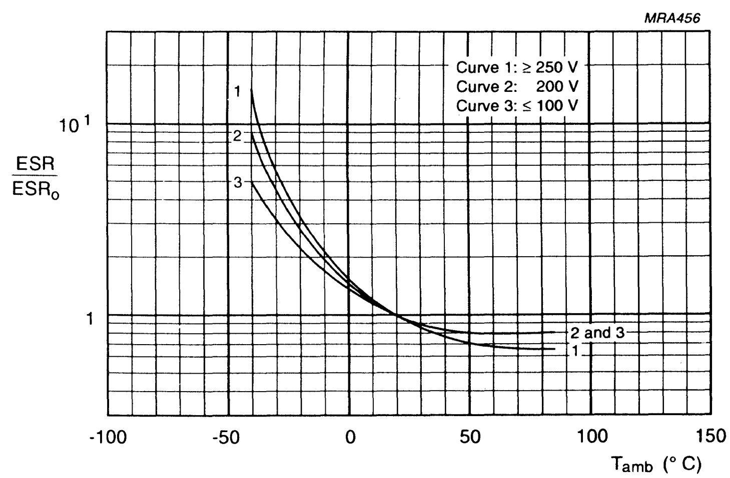
Fig.5 Multiplier of typical capacitance (C/C_0) as a function of ambient temperature.

Equivalent series resistance (ESR)



ESR_0 = typical ESR at 20 °C and 100 Hz.

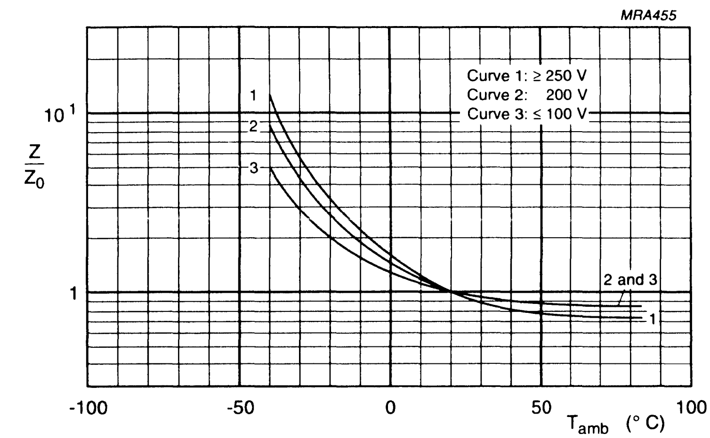
Fig.6 Multiplier of typical ESR (ESR/ESR_0) as a function of frequency.



ESR_0 = typical ESR at 20 °C and 100 Hz.

Fig.7 Multiplier of typical ESR (ESR/ESR_0) as a function of ambient temperature.

Impedance (Z)



Z_0 = typical impedance at 20 °C and 10 kHz.

Fig.8 Multiplier of typical impedance (Z/Z_0) as a function of ambient temperature.

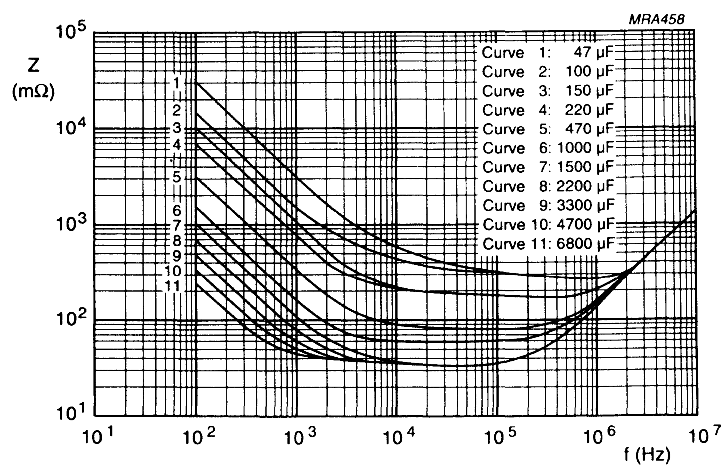


Fig.9 Typical impedance as a function of frequency at +20 °C; case size ∅22 x 25.

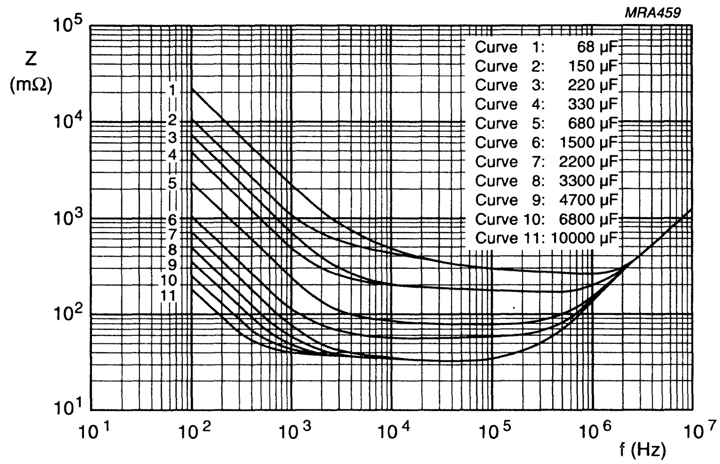


Fig.10 Typical impedance as a function of frequency at +20 °C; case size Ø22 x 30.

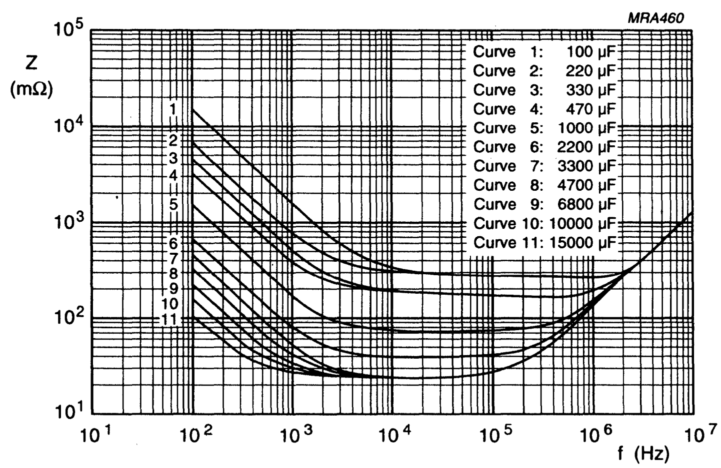


Fig.11 Typical impedance as a function of frequency at +20 °C; case sizes Ø25 x 30 and 22 x 40.

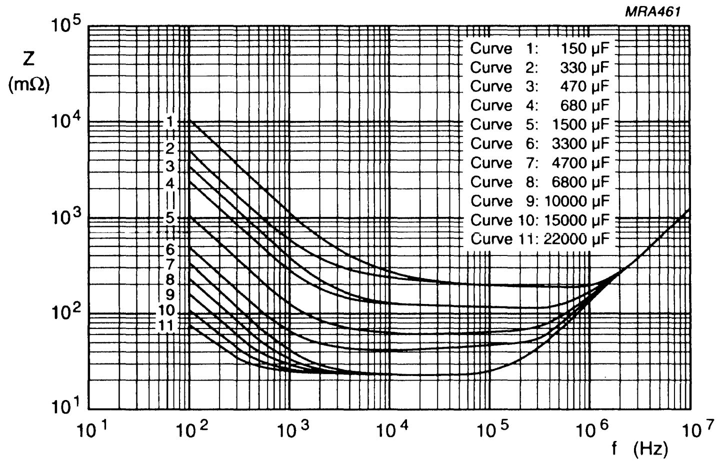


Fig.12 Typical impedance as a function of frequency at +20 °C; case sizes Ø30 x 30 and 25 x 40.

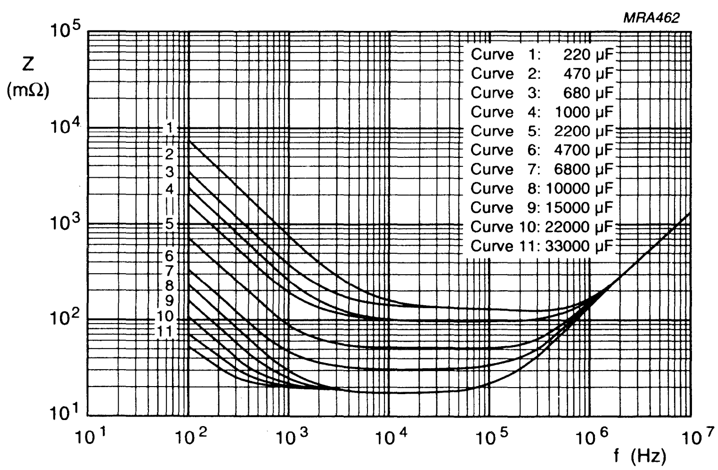


Fig.13 Typical impedance as a function of frequency at +20 °C; case sizes Ø30 x 40 and 25 x 50.

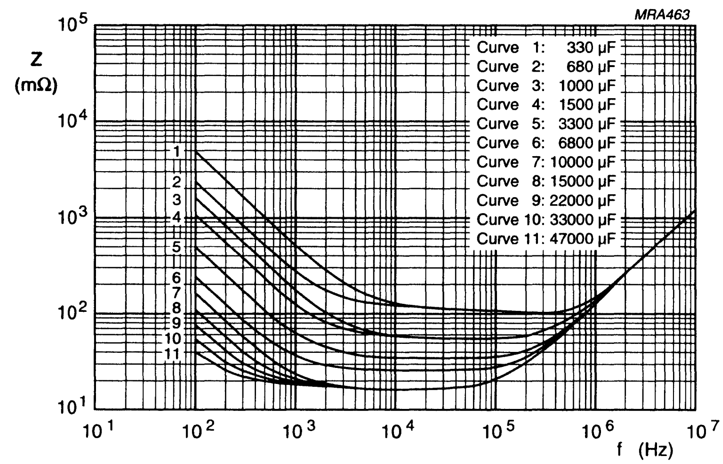


Fig.14 Typical impedance as a function of frequency at +20 °C; case sizes Ø35 x 40 and 30 x 50.

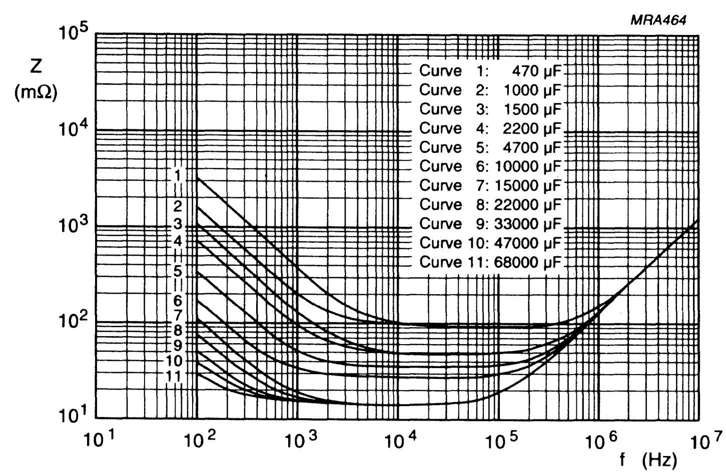
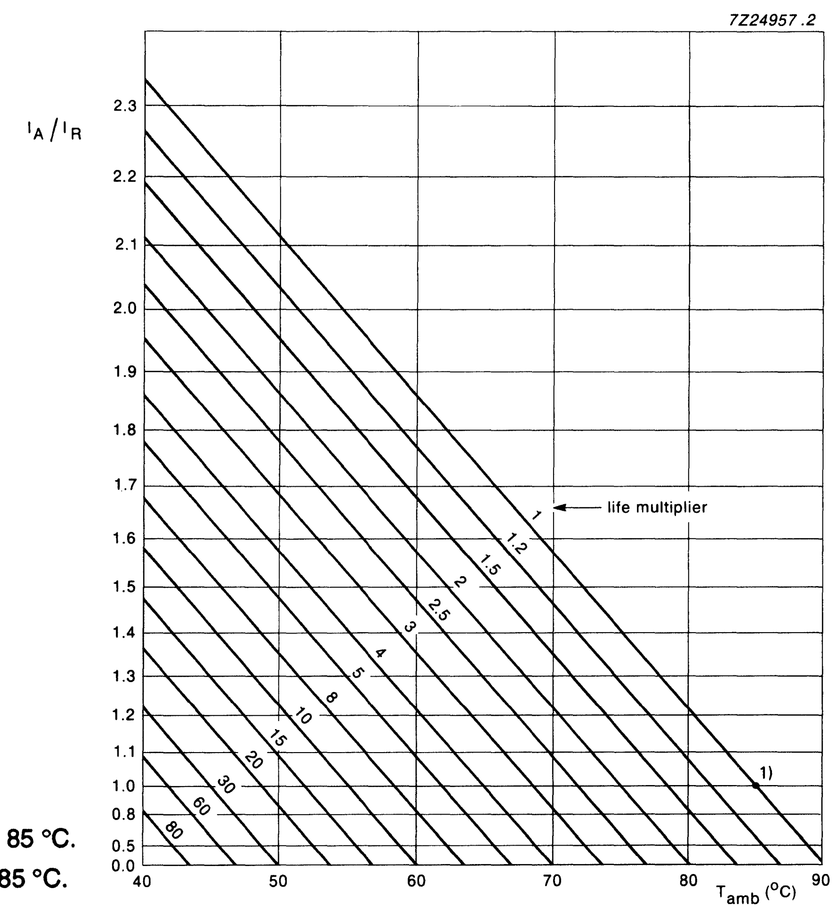


Fig.15 Typical impedance as a function of frequency at +20 °C; case size Ø35 x 50.

RIPPLE CURRENT and USEFUL LIFE

Table 6 Multiplier of ripple current I_R as a function of frequency.

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 10-35 V	U_R = 40-100 V	
50	0.93	0.91	
100	1.00	1.00	
200	1.04	1.05	
400	1.07	1.09	
1000	1.11	1.13	
2000	1.13	1.15	
4000	1.15	1.18	
≥10 000	1.18	1.22	



I_A = actual ripple current at 100 Hz and 85 °C.
I_R = rated ripple current at 100 Hz and 85 °C.

1) Useful life at 85 °C and I_R applied: 10 000 hours.

Fig.16 Life expectancy (useful life) as a function of ripple current load (I_A/I_R) and ambient temperature.

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 7

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 85 °C, U_R applied 5000 hours	U_R ≤100 V: ΔC/C ≤15% U_R >100 V: ΔC/C ≤10% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied 10 000 hours	ΔC/C ≤45% (U_R ≤100 V) ΔC/C ≤30% (U_R >100 V) tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit no visible damage total failure percentage: U_R ≤100 V: ≤1% U_R >100 V: ≤3%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301 group C 5a,4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C ≤±10% tan δ ≤1.2 x spec. limit I_{L5} ≤2 x spec. limit

NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Large types, minimized dimensions, cylindrical aluminium case, insulated with a blue sleeve
- Safety vent in the bottom of the aluminium case
- Charge and discharge proof
- Very long useful life: 10 000 hours/105 °C
- Extended temperature range: 105 °C
- Low ESR, high ripple current capability.

APPLICATIONS

- Computer, telecommunication and industrial systems
- Smoothing and filtering applications
- Standard and switched mode power supplies
- Energy storage in pulse systems.

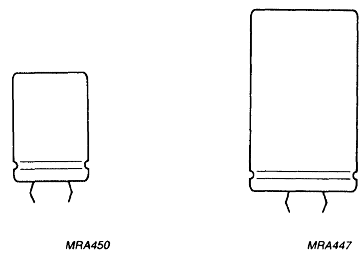


Fig.1 Component outlines.

QUICK REFERENCE DATA

	058
Case size (∅D_{nom} x L_{nom} in mm)	22 x 25 to 35 x 50
Rated capacitance range (E6/E12 series), C_R	330 to 47 000 µF
Tolerance on C_R	±20%
Rated voltage range, U_R	10 to 100 V
Category temperature range	–40 to +105 °C
Endurance test at 105 °C	5000 hours
Useful life at 105 °C	10 000 hours
Useful life at U_R, 40 °C and 1.9 x I_R applied	250 000 hours
Shelf life at 0 V, 105 °C	500 hours
Basic specifications	IEC 384-4, CECC 30 300, LL grade
Climatic category IEC 68 DIN 40040	 40/105/56 GMF

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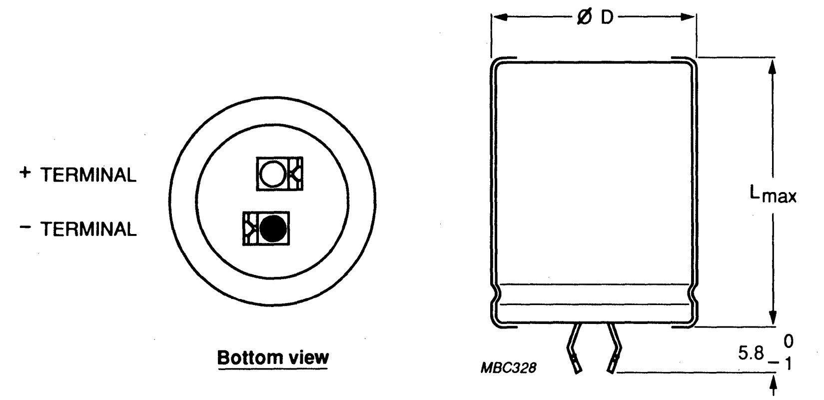
Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (**∅D x L** in **mm**) for 058 series

C_R (μF)	U_R (V)							
	10	16	25	35	40	50	63	100
330								22 x 25
470								22 x 30
680							22 x 25	25 x 30 22 x 40
1000						22 x 25	22 x 30	30 x 30 25 x 40
1500				22 x 25	22 x 25	22 x 30	25 x 30 22 x 40	30 x 40 25 x 50
2200			22 x 25	22 x 30	22 x 30	25 x 30 22 x 40	30 x 30 25 x 40	35 x 40 30 x 50
3300		22 x 25	22 x 30	25 x 30 22 x 40	25 x 30 22 x 40	30 x 30 25 x 40	30 x 40 25 x 50	35 x 50
4700	22 x 25	22 x 30	25 x 30 22 x 40	30 x 30 25 x 40	30 x 30 25 x 40	30 x 40 25 x 50	35 x 40 30 x 50	
6800	22 x 30	25 x 30 22 x 40	30 x 30 25 x 40	30 x 40 25 x 50	30 x 40 25 x 50	35 x 40 30 x 50	35 x 50	
10 000	25 x 30 22 x 40	30 x 30 25 x 40	30 x 40 25 x 50	35 x 40 30 x 50	35 x 40 30 x 50	35 x 50		
15 000	30 x 30 25 x 40	30 x 40 25 x 50	35 x 40 30 x 50	35 x 50	35 x 50			
22 000	30 x 40 25 x 50	35 x 40 30 x 50	35 x 50					
33 000	35 x 40 30 x 50	35 x 50						
47 000	35 x 50							

MECHANICAL DATA and PACKING QUANTITIES

Dimensions in mm.



The minus terminal can be marked with a black dot or with an imprinted minus sign.

Fig.2 Snap-in.

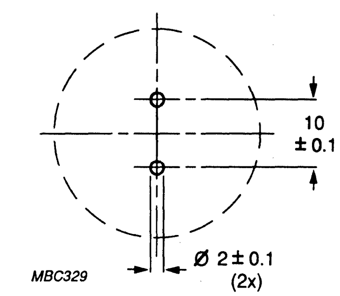


Fig.3 Piercing diagram.

Table 3 Dimensions in mm; mass in g

CASE SIZE $ØD_{nom} \times L_{nom}$	CASE CODE	$ØD_{max}$	L_{max}	APPROX. MASS	PACKING QUANTITIES (units per box)
22 x 25	2225	23	27	12	100
22 x 30	2230	23	32	16	100
22 x 35	2235	23	37	20	100
22 x 40	2240	23	42	23	100
25 x 30	2530	26.5	32	22	100
25 x 35	2535	26.5	37	24	100
25 x 40	2540	26.5	42	27	100
25 x 45	2545	26.5	47	32	100
25 x 50	2550	26.5	52	38	100
30 x 30	3030	31.5	32	30	100
30 x 35	3035	31.5	37	35	100
30 x 40	3040	31.5	42	40	100
30 x 45	3045	31.5	47	45	100
30 x 50	3050	31.5	52	50	100
35 x 30	3530	36.5	32	40	50
35 x 35	3535	36.5	37	48	50
35 x 40	3540	36.5	42	55	50
35 x 45	3545	36.5	47	63	50
35 x 50	3550	36.5	52	72	50

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Tables 4 and 5 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R = rated capacitance at 100 Hz

I_R = rated RMS ripple current at 100 Hz, 105 °C

I_{L1} = max. leakage current after 1 minute at U_R

I_{L5} = max. leakage current after 5 minutes at U_R

ESR = max. equivalent series resistance at 100 Hz

Z = max. impedance at 10 kHz.

Ordering Example

Electrolytic capacitors
2222 058

10 000 µF/25 V, ±20%

Case size 30 x 40 mm

Catalogue number:
2222 058 56103.

Table 4 Electrical data and ordering information for 058 series

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅D x L (mm)	CASE CODE	I_R 100 Hz 105 °C (A)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	CATALOGUE NUMBER 2222 . . . .
10	4700	22 x 25	2225	1.95	286	98	82	57	058 54472
	6800	22 x 30	2230	2.44	412	140	61	44	058 54682
	10 000	25 x 30	2530	2.81	604	204	54	42	058 54103
	10 000	22 x 40	2240	3.29	604	204	43	32	058 44103
	15 000	30 x 30	3030	3.53	904	304	42	34	058 54153
	15 000	25 x 40	2540	3.78	904	304	38	30	058 44153
	22 000	30 x 40	3040	4.62	1324	444	31	25	058 54223
	22 000	25 x 50	2550	4.68	1324	444	31	24	058 44223
	33 000	35 x 40	3540	5.15	1984	664	30	24	058 54333
	33 000	30 x 50	3050	5.70	1984	664	24	21	058 44333
	47 000	35 x 50	3550	6.23	2824	944	24	21	058 54473
16	3300	22 x 25	2225	1.90	321	110	86	57	058 55332
	4700	22 x 30	2230	2.36	455	154	65	44	058 55472
	6800	25 x 30	2530	2.75	657	222	56	42	058 55682
	6800	22 x 40	2240	3.18	657	222	46	32	058 45682
	10 000	30 x 30	3030	3.44	964	324	44	34	058 55103
	10 000	25 x 40	2540	3.66	964	324	40	30	058 45103
	15 000	30 x 40	3040	4.55	1444	484	32	25	058 55153
	15 000	25 x 50	2550	4.55	1444	484	32	24	058 45153
	22 000	35 x 40	3540	5.07	2116	708	31	24	058 55223
	22 000	30 x 50	3050	5.67	2116	708	25	21	058 45223
	33 000	35 x 50	3550	6.23	3172	1060	25	21	058 55333

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅D x L (mm)	CASE CODE	I_R 100 Hz 105 °C (A)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	CATALOGUE NUMBER 2222 . . . .
25	2200	22 x 25	2225	1.76	334	114	100	57	058 56222
	3300	22 x 30	2230	2.23	499	169	73	44	058 56332
	4700	25 x 30	2530	2.60	709	239	62	42	058 56472
	4700	22 x 40	2240	3.00	709	239	52	32	058 46472
	6800	30 x 30	3030	3.26	1024	344	49	34	058 56682
	6800	25 x 40	2540	3.49	1024	344	44	30	058 46682
	10 000	30 x 40	3040	4.37	1504	504	35	25	058 56103
	10 000	25 x 50	2550	4.37	1504	504	35	24	058 46103
	15 000	35 x 40	3540	4.91	2254	754	33	24	058 56153
	15 000	30 x 50	3050	5.43	2254	754	27	21	058 46153
	22 000	35 x 50	3550	6.07	3304	1104	27	21	058 56223
35	1500	22 x 25	2225	1.65	319	109	114	65	058 50152
	2200	22 x 30	2230	2.04	466	158	87	50	058 50222
	3300	25 x 30	2530	2.43	697	235	71	45	058 50332
	3300	22 x 40	2240	2.78	697	235	60	37	058 40332
	4700	30 x 30	3030	2.96	991	333	59	40	058 50472
	4700	25 x 40	2540	3.26	991	333	51	32	058 40472
	6800	30 x 40	3040	3.94	1432	480	42	29	058 50682
	6800	25 x 50	2550	4.10	1432	480	39	26	058 40682
	10 000	35 x 40	3540	4.18	2104	704	46	29	058 50103
	10 000	30 x 50	3050	4.98	2104	704	36	24	058 40103
	15 000	35 x 50	3550	5.21	3154	1054	36	24	058 50153
40	1500	22 x 25	2225	1.65	364	124	114	65	058 57152
	2200	22 x 30	2230	2.04	532	180	87	50	058 57222
	3300	25 x 30	2530	2.43	796	268	71	45	058 57332
	3300	22 x 40	2240	2.78	796	268	60	37	058 47332
	4700	30 x 30	3030	2.96	1132	380	59	40	058 57472
	4700	25 x 40	2540	3.26	1132	380	51	32	058 47472
	6800	30 x 40	3040	3.94	1636	548	42	29	058 57682
	6800	25 x 50	2550	4.10	1636	548	39	26	058 47682
	10 000	35 x 40	3540	4.18	2404	804	46	29	058 57103
	10 000	30 x 50	3050	4.98	2404	804	36	24	058 47103
	15 000	35 x 50	3550	5.21	3604	1204	36	24	058 57153

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅D x L (mm)	CASE CODE	I_R 100 Hz 105 °C (A)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)	CATALOGUE NUMBER 2222 . . . .
50	1000	22 x 25	2225	1.50	304	104	138	69	058 51102
	1500	22 x 30	2230	1.88	454	154	102	54	058 51152
	2200	25 x 30	2530	2.27	664	124	82	47	058 51222
	2200	22 x 40	2240	2.55	664	124	71	38	058 41222
	3300	30 x 30	3030	2.81	994	334	66	41	058 51332
	3300	25 x 40	2540	3.07	994	334	57	33	058 41332
	4700	30 x 40	3040	3.77	1414	474	47	30	058 51472
	4700	25 x 50	2550	3.85	1414	474	43	27	058 41472
	6800	35 x 40	3540	4.01	2044	684	49	30	058 51682
	6800	30 x 50	3050	4.74	2044	684	38	24	058 41682
	10 000	35 x 50	3550	5.04	3004	1004	38	24	058 51103
63	680	22 x 25	2225	1.17	261	90	228	150	058 58681
	1000	22 x 30	2230	1.46	382	130	170	115	058 58102
	1500	25 x 30	2530	1.76	571	193	137	85	058 58152
	1500	22 x 40	2240	2.00	571	193	115	85	058 48152
	2200	30 x 30	3030	2.27	836	281	101	70	058 58222
	2200	25 x 40	2540	2.40	836	281	94	70	058 48222
	3300	30 x 40	3040	3.07	1251	420	70	50	058 58332
	3300	25 x 50	2550	3.07	1251	420	70	50	058 48332
	4700	35 x 40	3540	3.65	1781	596	60	45	058 58472
	4700	30 x 50	3050	3.88	1781	596	53	45	058 48472
	6800	35 x 50	3550	4.58	2574	861	46	35	058 58682
100	330	22 x 25	2225	0.92	202	70	370	250	058 59331
	470	22 x 30	2230	1.14	286	98	280	190	058 59471
	680	25 x 30	2530	1.35	412	140	232	140	058 59681
	680	22 x 40	2240	1.57	412	140	190	140	058 49681
	1000	30 x 30	3030	1.79	604	204	163	115	058 59102
	1000	25 x 40	2540	1.85	604	204	158	115	058 49102
	1500	30 x 40	3040	2.45	904	304	111	85	058 59152
	1500	25 x 50	2550	2.38	904	304	116	85	058 49152
	2200	35 x 40	3540	3.05	1324	444	86	65	058 59222
	2200	30 x 50	3050	3.13	1324	444	82	65	058 49222
	3300	35 x 50	3550	3.84	1984	664	64	50	058 59332

Voltage

Surge voltage for short periods ≤250 V versions	$U_s = 1.15 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$

Equivalent series inductance (ESL)

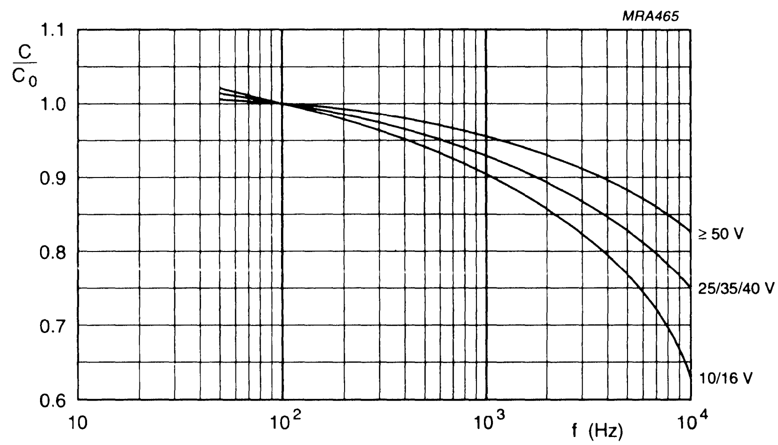
Typical ESL for all case sizes	19 nH
Maximum ESL for all case sizes	25 nH

Marking

The capacitors are marked (where possible) with the following information:

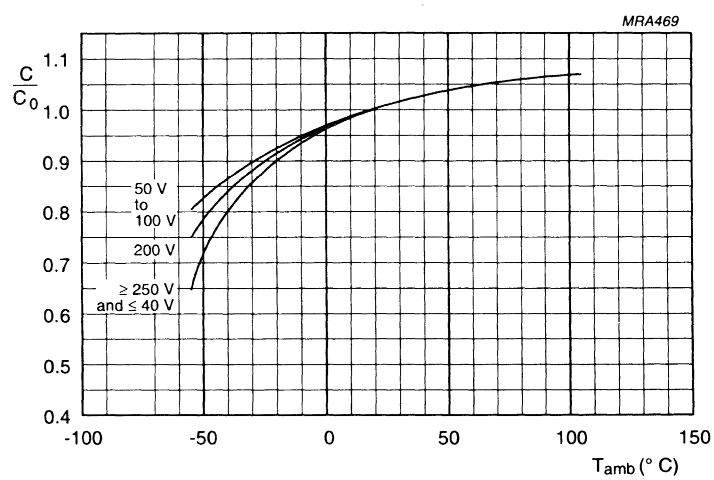
- Rated capacitance
- Tolerance code on rated capacitance (M for ±20%)
- Rated voltage
- Climatic category (in accordance with IEC 68)
- Date code (year and week) in accordance with IEC 62
- Code for factory of origin
- Name of manufacturer
- '–' sign to indicate the negative terminal, visible from the top and side of the capacitor
- Code number (last 8 digits)
- Code for basic specification (in accordance with IEC 384-4-1, CECC 30 301).

Capacitance (C)



C/C_0 = capacitance at 20 °C and 100 Hz.

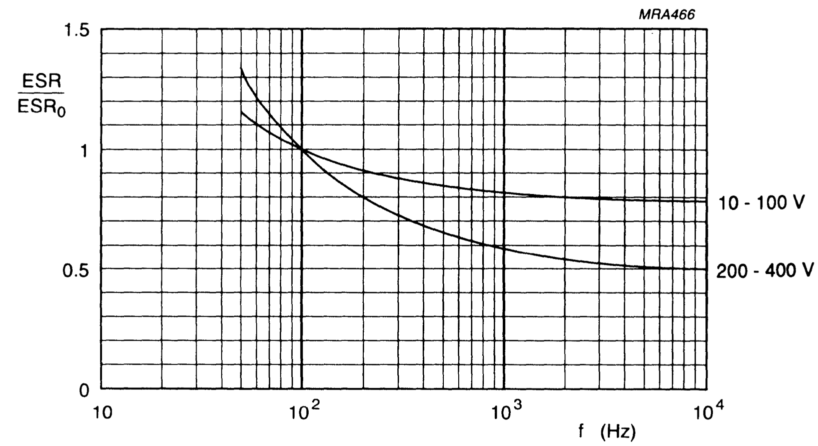
Fig.4 Multiplier of typical capacitance (C/C_0) as a function of frequency.



C/C_0 = capacitance at 20 °C and 100 Hz.

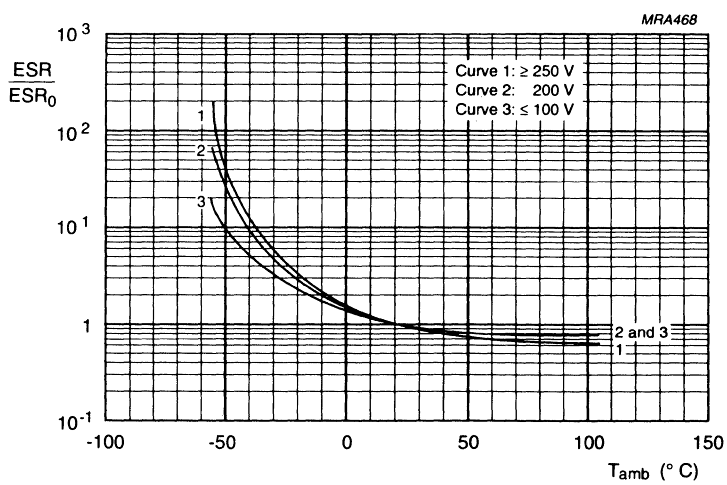
Fig.5 Multiplier of typical capacitance (C/C_0) as a function of ambient temperature.

Equivalent series resistance (ESR)



ESR_0 = typical ESR at 20 °C and 100 Hz.

Fig.6 Multiplier of typical ESR (ESR/ESR_0) as a function of frequency.



ESR_0 = typical ESR at 20 °C and 100 Hz.

Fig.7 Multiplier of typical ESR (ESR/ESR_0) as a function of ambient temperature.

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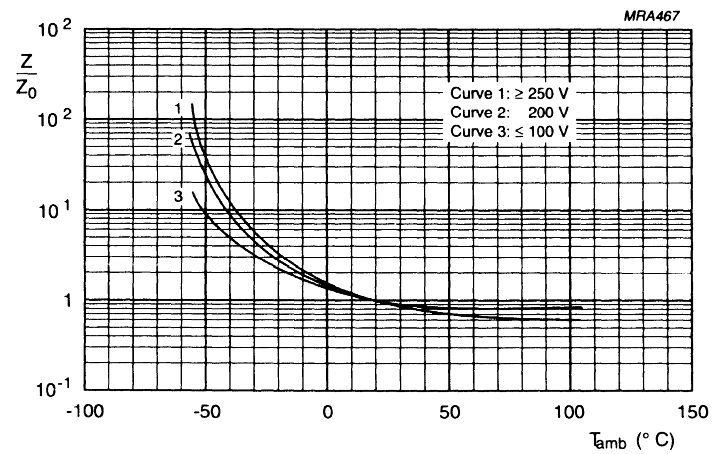
Impedance (Z)



Z_0 = typical impedance at 20 °C and 10 kHz.

Fig.8 Multiplier of typical impedance (Z/Z_0) as a function of ambient temperature.

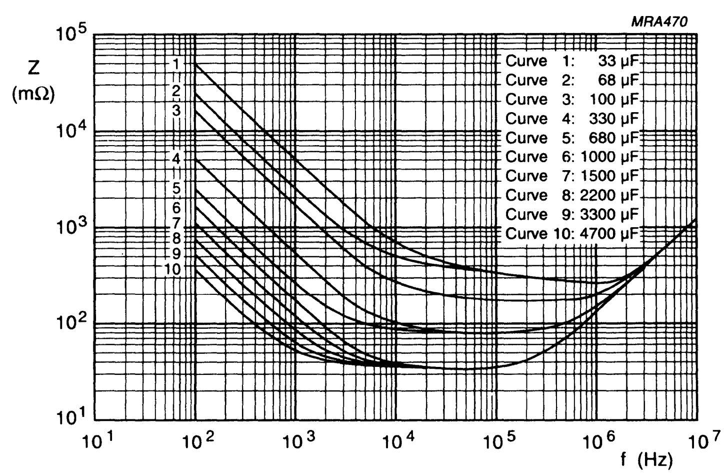


Fig.9 Typical impedance as a function of frequency at +20 °C; case size Ø22 x 25.

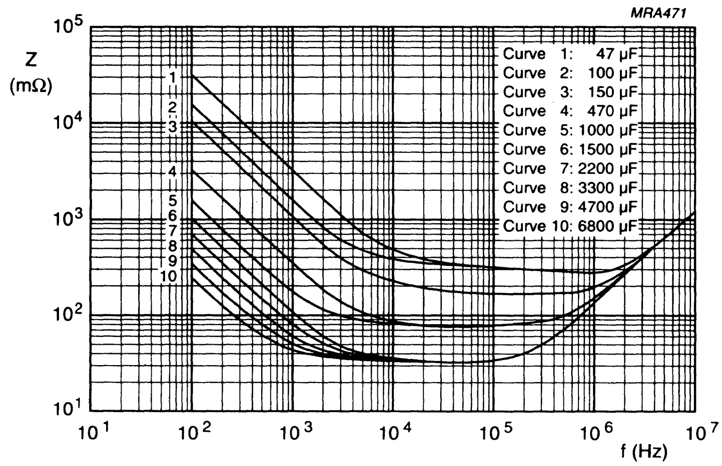


Fig.10 Typical impedance as a function of frequency at +20 °C; case size ∅22 x 30.

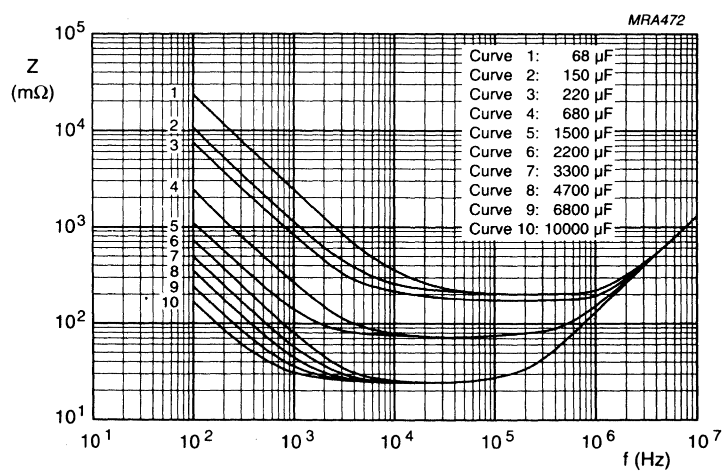


Fig.11 Typical impedance as a function of frequency at +20 °C; case sizes ∅25 x 30 and 22 x 40.

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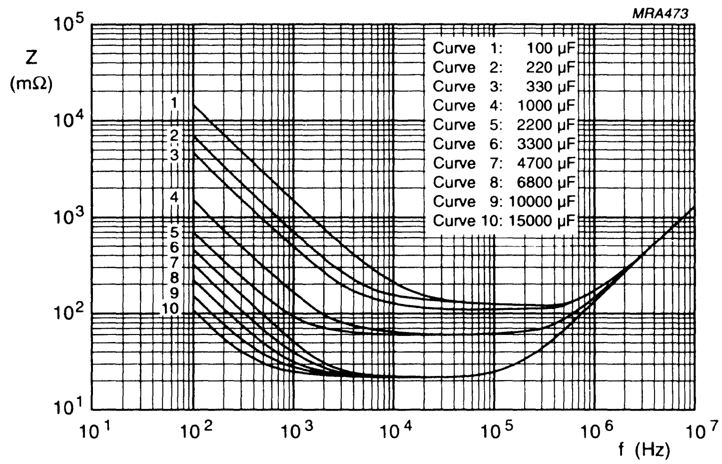

Fig.12 Typical impedance as a function of frequency at +20 °C; case sizes ∅30 x 30 and 25 x 40.

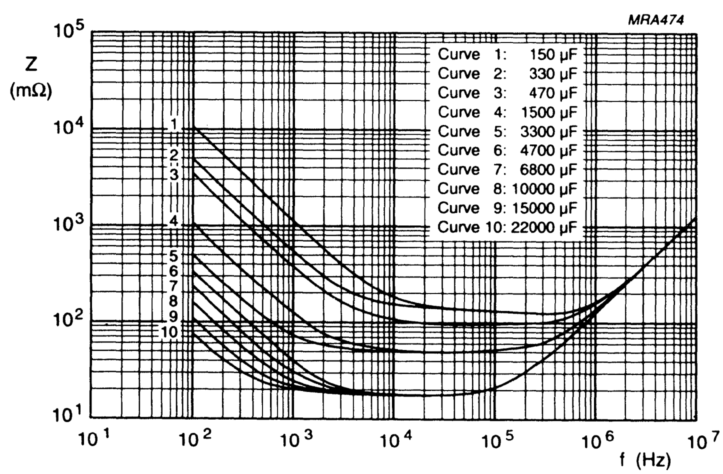

Fig.13 Typical impedance as a function of frequency at +20 °C; case sizes ∅30 x 40 and 25 x 50.

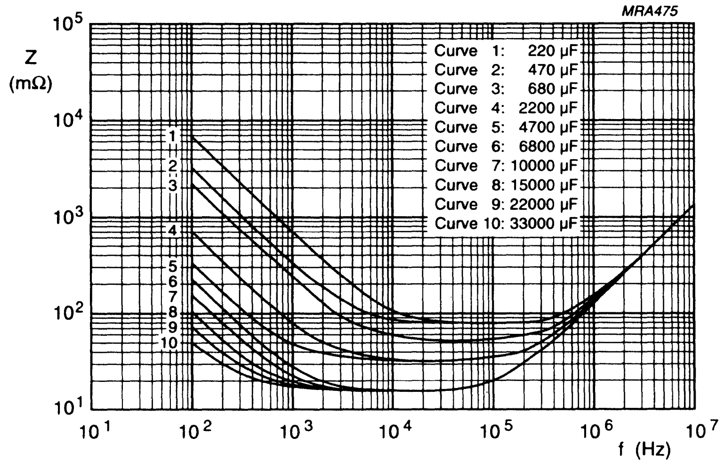

Fig.14 Typical impedance as a function of frequency at +20 °C; case sizes Ø35 x 40 and 30 x 50.

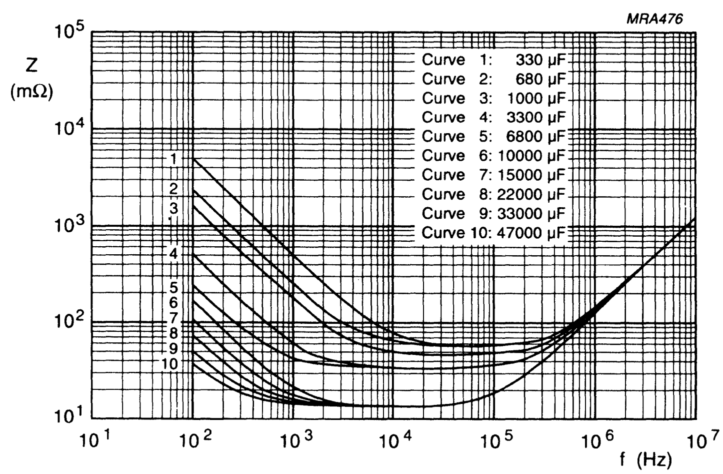

Fig.15 Typical impedance as a function of frequency at +20 °C; case size Ø35 x 50.

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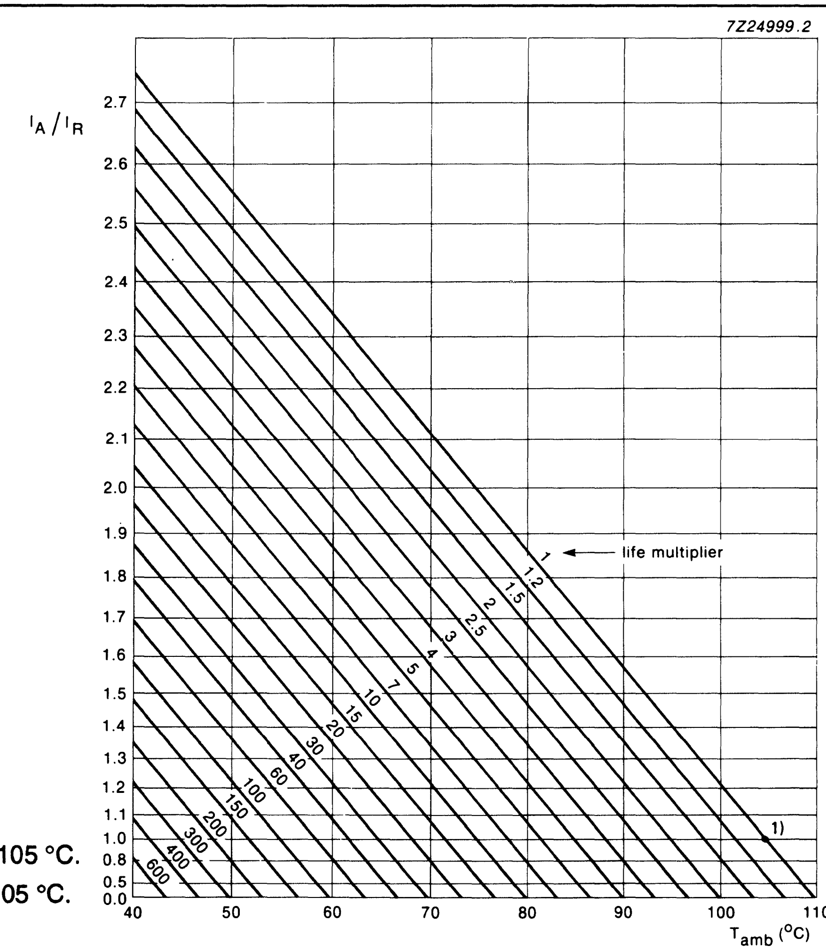
RIPPLE CURRENT and USEFUL LIFE

Table 6 Multiplier of ripple current I_R as a function of frequency

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 10-35 V	U_R = 40-100 V	
50	0.93	0.91	
100	1.00	1.00	
200	1.04	1.05	
400	1.07	1.09	
1000	1.11	1.13	
2000	1.13	1.15	
4000	1.15	1.18	
≥10 000	1.18	1.22	



I_A = actual ripple current at 100 Hz and 105 °C.
I_R = rated ripple current at 100 Hz and 105 °C.

1) Useful life at 105 °C and I_R applied: 10 000 hours.

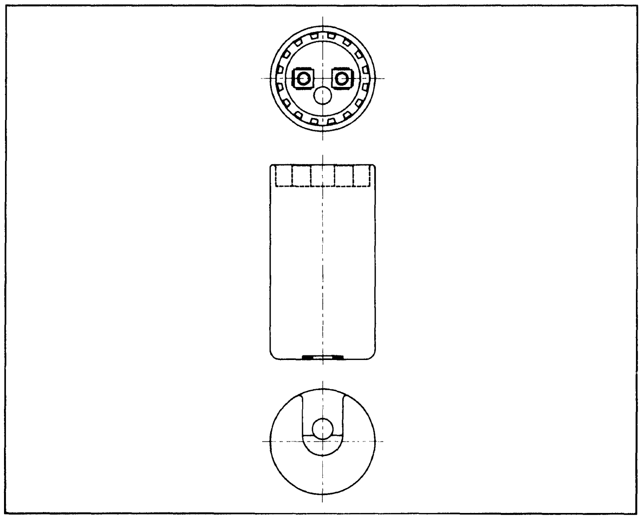
Fig.16 Life expectancy (useful life) as a function of ripple current load I_A/I_R and ambient temperature.

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 7

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 105 °C, U_R applied 5000 hours	U_R ≤100 V: ΔC/C ≤15% U_R >100 V: ΔC/C ≤10% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 105 °C, U_R and I_R applied 10 000 hours	ΔC/C ≤45% (U_R ≤100 V) ΔC/C ≤30% (U_R >100 V) tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit no visible damage total failure percentage: U_R ≤100 V: ≤1% U_R >100 V: ≤3%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301 group C 5a,4.17	T_{amb} = 105 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C ≤±10% tan δ ≤1.2 x spec. limit I_{L5} ≤2 x spec. limit



A.C. Motor Start Capacitor

Description

Philips Components Series 3500 A.C. motor-start capacitor is an electrochemical device consisting of compactly wound aluminum foils separated by layers of paper, which are impregnated with a conducting electrolyte. Etching of the foil prior to formation and winding increases both the effective foil surface area and the capacitance per unit volume of the finished capacitor. The entire assembly is housed in a molded plastic container. Capacitors are rated for operation in ambient temperatures from −40°C to +65°C, and at a frequency of 50 Hz to 60 Hz.

Case style "B" is available with a choice of terminals and mounting methods. Four terminal types are available. All have a special metal to metal under cover connection for positive terminal contact with the capacitor roll tabs. On special order, units can be supplied with bleeder resistors soldered across the terminals.

Features

- Plastic case requires no insulation.
- Stable electrical characteristics after 75,000 starts (110VAC and 125VAC).
- Type 3535 meets EIA Type I specifications.
- Type 3534 meets EIA Type II specifications.
- Longer life due to cooler operation.
- Four terminal types available.

Case Dimensions and Styles

Case Size	Dimensions in Inches		
	D ±0.010	H ±0.020	Case Style B W (Max)
1	1 7/16	2 3/4	0.032
2	1 7/16	3 3/8	.032
3	1 7/16	4 3/8	.032
4	1 13/16	3 3/8	.032
5	1 13/16	4 3/8	.032
6	2 1/16	3 3/8	.032
7	2 1/16	4 3/8	.032
8	2 9/16	4 3/8	.032

End Caps

Bottom Lead Hole		Top Lead Hole	
Case Size	Catalog No.	Case Size	Catalog No.
1, 2, 3	614A766AAP1	1, 2, 3	614A766ABP1
4, 5	614A766AAP2	4, 5	614A766ABP2
6, 7	614A766AAP3	6, 7	614A766ABP3
8	614A766AAP4	8	614A766ABP4

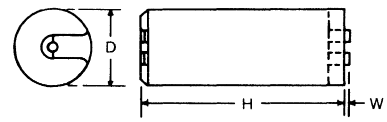
Brackets

Case Size	Catalog No.	A	B	C	D	E
3, 5, 7, 8	614A765ABP1	5.015	4.656	2.0	—	2.078
2, 4, 6	614A765ABP2	4.015	3.650	1.703	.906	1.578
1	614A765ABP3	3.374	3.015	1.062	.586	1.258

Leads and Terminals

If required, leads (with or without terminals) can be supplied at extra cost. Standard lengths vary from 4 to 28 inches. Lead wire is #18 stranded copper conductor with 0.062″ min. thickness thermoplastic insulation. Insulation is stripped ½″ from ends, and bare lead is tinned. Upon request, leads can be supplied with terminals affixed to one end. Either eyelet or female quick-connect terminals are available.

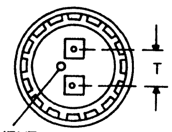
Case Outline Drawing



Style B
(recessed cover depth)

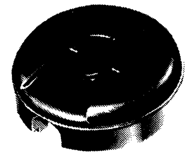
Terminal Spacing

Case Size	T (in.) ± .062
1, 2, 3	0.500
4, 5	0.625
6, 7, 8	0.813

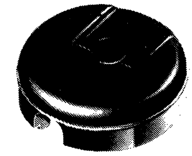


End Caps

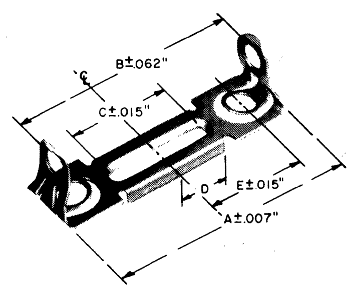
Bottom Lead Hole



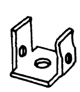
Top Lead Hole



Bracket Drawing

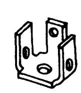


Terminals



Type A
Double QC

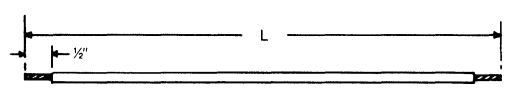
Type B
Single QC

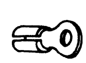


Type C
Double QC
with solder lug

Type D
Solder lug

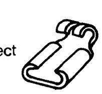
(Quick-connect terminals are also suitable for soldered connections).





Eyelet
terminal

Female
quick-connect
terminal



How To Specify

Philips Components' A.C. Motor Start capacitors can be completely specified using the following designations:

35 35 B I A 0021 A 110

- **35** — Philips Components AC Motor Start Capacitor
- **35** — Performance Class
  - 34 = Type II light duty
  - 35 = Type I heavy duty
  - 30 = Special
- **B** — Case Style: B = Recessed
- **I** — Case Code (see rating tables)
- **A** — Terminal Style (see Physical specs)
- **0021** — Minimum µF rating
- **A** — Bracket & End Cap Code
  - A = No Bracket or End Cap
  - B = End Cap Only
  - C = End Cap and Bracket
  - D = Bracket Only
- **110** — AC RMS Rated Volts

Standard Capacitance Values EIA Type I

110 Volts AC

µF Min-Max	Case Size	Part Number
21-25	1	3535B1A0021A110**
25-30	1	3535B1A0025A110**
30-36	1	3535B1A0030A110**
36-43	1	3535B1A0036A110**
43-53	1	3535B1A0043A110**
47-56	1	3535B1A0047A110**
53-64	1	3535B1A0053A110**
64-77	1	3535B1A0064A110**
72-88	1	3535B1A0072A110**
88-108	1	3535B1A0088A110**
108-130	1	3535B1A0108A110**
124-149	1	3535B1A0124A110**
130-156	1	3535B1A0130A110**
145-175	1	3535B1A0145A110**
161-193	1	3535B1A0161A110**
189-227	2	3535B2A0189A110**
216-259	2	3535B2A0216A110**
233-280	2	3535B2A0233A110**
243-292	4	3535B4A0243A110**
270-324	4	3535B4A0270A110**
340-408	4	3535B4A0340A110**
378-440	4	3535B4A0378A110**
400-480	4	3535B4A0400A110**
430-516	4	3535B4A0430A110**
460-552	4	3535B4A0460A110**
540-648	7	3535B7A0540A110**
590-708	7	3535B7A0590A110**
710-850	8	3535B8A0710A110**

125 Volts AC

µF Min-Max	Case Size	Part Number
21-25	1	3535B1A0021A125**
25-30	1	3535B1A0025A125**
30-36	1	3535B1A0030A125**
36-43	1	3535B1A0036A125**
43-53	1	3535B1A0043A125**
47-56	1	3535B1A0047A125**
53-64	1	3535B1A0053A125**
64-77	1	3535B1A0064A125**
72-88	1	3535B1A0072A125**
88-108	1	3535B1A0088A125**
108-130	1	3535B1A0108A125**
124-149	1	3535B1A0124A125**
130-156	1	3535B1A0130A125**
145-175	2	3535B2A0145A125**
161-193	2	3535B2A0161A125**
189-227	2	3535B2A0189A125**
216-259	4	3535B4A0216A125**
233-280	4	3535B4A0233A125**
243-292	4	3535B4A0243A125**
270-324	4	3535B4A0270A125**
340-408	5	3535B5A0340A125**
378-440	5	3535B5A0378A125**
400-480	5	3535B5A0400A125**
430-516	7	3535B7A0430A125**
460-552	7	3535B7A0460A125**
560-648	8	3535B8A0560A125**

μF Min-Max	Case Size	Part Number
165 Volts AC		
21-25	1	3535B1A0021A165**
25-30	1	3535B1A0025A165**
30-36	1	3535B1A0030A165**
36-43	1	3535B1A0036A165**
43-53	1	3535B1A0043A165**
47-56	1	3535B1A0047A165**
53-64	1	3535B1A0053A165**
64-77	1	3535B1A0064A165**
72-88	1	3535B1A0072A165**
88-108	2	3535B1A0088A165**
108-130	2	3535B2A0108A165**
124-149	4	3535B4A0124A165**
130-156	4	3535B4A0130A165**
145-175	4	3535B4A0145A165**
161-193	4	3535B4A0161A165**
189-227	4	3535B4A0189A165**
216-259	5	3535B5A0216A165**
233-280	5	3535B5A0233A165**
243-292	5	3535B5A0243A165**
270-324	5	3535B5A0270A165**
340-408	7	3535B7A0340A165**
400-480	8	3535B8A0400A165**
220 Volts AC		
21-25	1	3535B1A0021A220**
25-30	1	3535B1A0025A220**
30-36	1	3535B1A0030A220**
36-43	2	3535B2A0036A220**
43-53	2	3535B2A0043A220**
47-56	2	3535B2A0047A220**
53-64	4	3535B4A0053A220**
64-77	4	3535B4A0064A220**
72-88	4	3535B4A0072A220**
88-108	4	3535B4A0088A220**
108-130	5	3535B5A0108A220**
124-149	5	3535B5A0124A220**
130-156	5	3535B5A0130A220**
145-175	7	3535B7A0145A220**
161-193	8	3535B8A0161A220**
189-227	8	3535B8A0189A220**
250 Volts AC		
21-25	1	3535B1A0021A250**
25-30	1	3535B1A0025A250**
30-36	2	3535B2A0030A250**
36-43	2	3535B2A0036A250**
43-53	4	3535B4A0043A250**
47-56	4	3535B4A0047A250**
53-64	4	3535B4A0053A250**
64-77	4	3535B4A0064A250**
72-88	4	3535B4A0072A250**
88-108	5	3535B5A0088A250**
108-130	5	3535B5A0108A250**
124-149	7	3535B7A0124A250**
130-156	8	3535B8A0130A250**
145-175	8	3535B8A0145A250**
161-193	8	3535B8A0161A250**

μF Min-Max	Case Size	Part Number
330 Volts AC		
21-25	2	3535B2A0021A330**
25-30	2	3535B2A0025A330**
30-36	4	3535B4A0030A330**
36-43	4	3535B4A0036A330**
43-53	4	3535B4A0043A330**
47-56	4	3535B4A0047A330**
53-64	5	3535B5A0053A330**
64-77	5	3535B5A0064A330**
72-88	5	3535B5A0072A330**
88-108	7	3535B7A0088A330**
108-130	8	3535B8A0108A330**

NOTE: **Last two digits of part number to be assigned by the computer for individual customer identification. Part numbers shown are for standard parts. Recessed case, double quick connect terminals.

Standard Capacitance Values EIA. Type II

µF Min-Max	Case Size	Part Number
110 Volts AC		
21-25	1	3534B1A0021A110**
25-30	1	3534B1A0025A110**
30-36	1	3534B1A0030A110**
36-43	1	3534B1A0036A110**
43-53	1	3534B1A0043A110**
47-56	1	3534B1A0047A110**
53-64	1	3534B1A0053A110**
64-77	1	3534B1A0064A110**
72-88	1	3534B1A0072A110**
88-108	1	3534B1A0088A110**
108-130	1	3534B1A0108A110**
124-149	1	3534B1A0124A110**
130-156	1	3534B1A0130A110**
145-175	1	3534B1A0145A110**
161-193	1	3534B1A0161A110**
189-227	1	3534B1A0189A110**
216-259	2	3534B2A0216A110**
233-280	2	3534B2A0233A110**
243-292	2	3534B2A0243A110**
270-324	2	3534B2A0270A110**
340-408	4	3534B4A0340A110**
378-440	4	3534B4A0378A110**
400-480	4	3534B4A0400A110**
430-516	4	3534B4A0430A110**
460-552	4	3534B4A0460A110**
540-648	5	3534B5A0540A110**
590-708	5	3534B5A0590A110**
710-850	7	3534B7A0710A110**
829-995	7	3534B7A0829A110**
1000-1200	8	3534B8A1000A110**

µF Min-Max	Case Size	Part Number
125 Volts AC		
21-25	1	3534B1A0021A125**
25-30	1	3534B1A0025A125**
30-36	1	3534B1A0030A125**
36-43	1	3534B1A0036A125**
43-53	1	3534B1A0043A125**
47-56	1	3534B1A0047A125**
53-64	1	3534B1A0053A125**
64-77	1	3534B1A0064A125**
72-88	1	3534B1A0072A125**
88-108	1	3534B1A0088A125**
108-130	1	3534B1A0108A125**
124-149	1	3534B1A0124A125**
130-156	1	3534B1A0130A125**
145-175	1	3534B1A0145A125**
161-193	1	3534B1A0161A125**
189-227	2	3534B2A0189A125**
216-259	2	3534B2A0216A125**
233-280	2	3534B2A0233A125**
243-292	3	3534B3A0243A125**
270-324	3	3534B3A0270A125**
340-408	4	3534B4A0340A125**
378-440	4	3534B4A0378A125**
400-480	4	3534B4A0400A125**
430-516	4	3534B4A0430A125**
460-552	4	3534B4A0460A125**
560-648	5	3534B5A0560A125**
645-774	7	3534B7A0645A125**
829-995	8	3534B8A0829A125**
165 Volts AC		
21-25	1	3534B1A0021A165**
25-30	1	3534B1A0025A165**
30-36	1	3534B1A0030A165**
36-43	1	3534B1A0036A165**
43-53	1	3534B1A0043A165**
47-56	1	3534B1A0047A165**
53-64	1	3534B1A0053A165**
64-77	1	3534B1A0064A165**
72-88	1	3534B1A0072A165**
88-108	1	3534B1A0088A165**
108-130	2	3534B2A0108A165**
124-149	2	3534B2A0124A165**
130-156	4	3534B4A0130A165**
145-175	4	3534B4A0145A165**
161-193	4	3534B4A0161A165**
189-227	4	3534B4A0189A165**
216-259	4	3534B4A0216A165**
233-280	5	3534B5A0233A165**
243-292	5	3534B5A0243A165**
270-324	5	3534B5A0270A165**
340-408	7	3534B7A0340A165**
400-480	7	3534B7A0400A165**
460-552	8	3534B8A0460A165**

µF Min-Max	Case Size	Part Number
220 Volts AC		
21-25	1	3534B1A0021A220**
25-30	1	3534B1A0025A220**
30-36	1	3534B1A0030A220**
36-43	1	3534B1A0036A220**
43-53	2	3534B2A0043A220**
47-56	2	3534B2A0047A220**
53-64	2	3534B2A0053A220**
64-77	4	3534B4A0064A220**
72-88	4	3534B4A0072A220**
88-108	4	3534B4A0088A220**
108-130	4	3534B4A0108A220**
124-149	5	3534B5A0124A220**
130-156	5	3534B5A0130A220**
145-175	7	3534B7A0145A220**
161-193	7	3534B7A0161A220**
189-227	7	3534B7A0189A220**
233-280	8	3534B8A0233A220**
270-324	8	3534B8A0270A220**
250 Volts AC		
21-25	1	3534B1A0021A250**
25-30	1	3534B1A0025A250**
30-36	2	3534B2A0030A250**
36-43	2	3534B2A0036A250**
43-53	2	3534B2A0043A250**
47-56	2	3534B2A0047A250**
53-64	4	3534B4A0053A250**
64-77	4	3534B4A0064A250**
72-88	4	3534B4A0072A250**
88-108	5	3534B5A0088A250**
108-130	5	3534B5A0108A250**
124-149	5	3534B5A0124A250**
130-156	5	3534B5A0130A250**
145-175	7	3534B7A0145A250**
161-193	7	3534B7A0161A250**
189-227	8	3534B8A0189A250**
233-280	8	3534B8A0233A250**
330 Volts AC		
21-25	2	3534B2A0021A330**
25-30	2	3534B2A0025A330**
30-36	4	3534B4A0030A330**
36-43	4	3534B4A0036A330**
43-53	4	3534B4A0043A330**
47-56	4	3534B4A0047A330**
53-64	5	3534B5A0053A330**
64-77	5	3534B5A0064A330**
72-88	5	3534B5A0072A330**
88-108	7	3534B7A0088A330**
108-130	8	3534B8A0108A330**
124-149	8	3534B840124A330**
145-174	8	3534B8A0145A330**

NOTE: **Last two digits of part number to be assigned by the computer for individual customer identification. Part numbers shown are for standard parts. Recessed case, double quick connect terminals.

Performance Specifications

1. **Temperature**

   1.1 Operating. These capacitors are designed to operate within the ambient temperature range of −40°C to 65°C.

   1.2 Storage. These capacitors may be subjected, without permanent damage, to conditions in transit where temperatures range from −55°C to +95°C.

   1.3 Tolerance. Unless otherwise specified, temperature tolerance shall be ±3°C.

2. **Frequency**

   Unless otherwise specified, frequency shall be 50-60 Hz.

3. **Voltage Rating**

   The rated voltage is the rms value of AC voltage at which the capacitor may be operated at its normal duty cycle and maximum ambient temperature.

4. **Capacitance and Power Factor**

   4.1 Measurement. Using the circuit shown in Fig. 1, apply rated voltage to the capacitor and measure current and power dissipated. Current shall be measured within 3 seconds, dissipated power within 4 seconds after application of rated voltage.

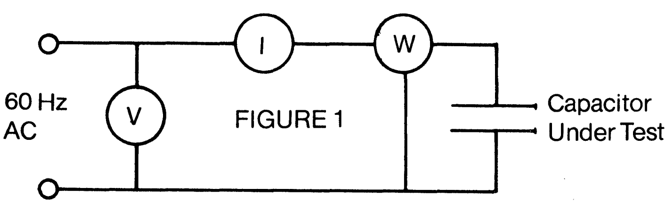


FIGURE 1

4.2 Temperature. Measurement shall be made at, or referred to, a temperature of 25°C.

4.3 Calculation of Capacitance and Power Factor.

$$C = \frac{I \times 10^6}{2\pi f V} \qquad \%PF = \frac{W}{VI} \times 100$$

Where C is capacitance in μFs
I is current in amperes
π is a constant (3.14)
f is frequency in hertz
V is applied voltage
PF is the power factor
W is power dissipated in watts

4.4 Requirements. Capacitance shall be within specified limits and the power factor shall not exceed 10%.

5. **Life Test***

   5.1 Capacitors shall be placed in a circulating air oven at an ambient temperature of 65°C. Spacing between capacitors must be at least 1″ and capacitors must not be subjected to direct radiation from heating elements. Circulation of air shall be sufficient to keep the temperature, within six (6) inches of the capacitor, below 68°C.

*Caution—Confine capacitor(s) under test to isolate all electrical connections for the safety of personnel.

5.1.1 A resistance equivalent to approximately 10% of the capacitor impedance shall be connected in series with each capacitor. A resistor of approximately 1000 ohms shall be connected in parallel with each capacitor.

5.1.2 Rated voltage shall be applied to the capacitor resistor combination for 3535 capacitors EIA Type I as specified below. Table is per EIA Standard RS-463.

Rated Voltage	Voltage Cycle	Duty Cycle	Minimum Number Starts
110, 115 and 125	2 times per minute ¾ sec. on; 29¼ sec. off.	0.0250	75,000
165, 220, 250 and 330	1 time per minute 1 sec. on; 59 sec. off.	0.0167	40,000

5.1.3 Rated voltage shall be applied to the capacitor resistor combination for 3534 capacitors EIA Type II as specified below. Table is per EIA Standard RS-463.

Rated Voltage, Test Voltage as (rms)	Capacitance Rating (mfd)		Duty Cycle		Duration of Test* (Number of Starts)
	From	To	Seconds On	Seconds Off	
110	21-25	124-149	¾	29¼	50,000
	130-156	243-292	1	59	50,000
	270-324	378-454	1	89	33,500
	400-480	540-648	1	119	25,000
	590-708	850-1020	1	179	16,500
	1000-1200	1280-1546	1	239	12,500
115	21-25	108-130	¾	29¼	50,000
	124-149	189-227	1	59	50,000
	216-259	340-408	1	89	33,500
	378-454	460-552	1	119	25,000
	540-648	815-978	1	179	16,500
	829-995	1020-1224	1	239	12,500
125	21-25	88-106	¾	29¼	50,000
	108-130	145-174	1	59	50,000
	161-193	233-280	1	89	33,500
	243-292	378-454	1	119	25,000
	400-480	590-708	1	179	16,500
	645-774	800-960	1	239	12,500
165	21-25	88-106	1	59	33,500
	108-130	124-149	1	89	33,500
	130-156	216-259	1	119	25,000
	233-280	340-408	1	179	16,500
	378-454	590-708	1	239	12,500

Rated Voltage, Test Voltage as (rms)	Capacitance Rating (mfd)		Duty Cycle		Duration of Test* (Number of Starts)
	From	To	Seconds On	Seconds Off	
220	21-25	43-52	1	59	33,500
	37-56	72-86	1	89	33,500
	88-106	145-174	1	119	25,000
	161-193	243-292	1	179	16,500
	270-324	430-516	1	239	12,500
250	21-25	30-36	1	59	33,500
	36-43	64-77	1	89	33,500
	72-86	88-106	1	119	25,000
	108-130	189-227	1	179	16,500
	216-259	324-389	1	239	12,500
330	21-25	21-25	1	59	33,500
	25-30	30-36	1	89	33,500
	36-43	64-77	1	119	25,000
	72-86	88-106	1	179	16,500
	108-130	130-156	1	239	12,500

*The number of starts shown in this column are reduced starts for accelerated testing so that test time does not exceed 35 days. Type 2 capacitors should be capable of 50,000 starts for ratings to 125 volts and 40,000 starts for higher voltages.

5.2 Upon completion of the life test, the capacitors shall be returned to room ambient for a minimum of 24 hours. The capacitors shall then meet the following requirements:

5.2.1 Capacitance, when measured per paragraph 4, shall not differ from the initial measured value by more than 25%.

5.2.2 The power factor, when measured per paragraph 4, shall not exceed 20%.

6. **Overvoltage Test**
Capacitors shall withstand, without breakdown or visible mechanical damage, 140% of rated voltage for one second at room temperature (EIA Type I capacitors only).

7. **Terminal Strength**
At the point of normal lead connection, terminals shall withstand a force of 5 pounds applied gradually in any direction for a period of one minute. There shall be no loosening of the terminals or damage to the terminal or seal.

8. **Case Insulation**
Capacitors are designed to withstand a 1500-volt rms 60-cycle voltage applied for 5 seconds between terminals and case without breakdown or flashover.

9. **Vibration**
Capacitors shall be clamped rigidly to a vibration platform and subjected to a simple harmonic motion having a maximum peak-to-peak amplitude of .06 inches and a maximum acceleration of 10g. The frequency of vibration shall be varied linearly between 10 and 55 cycles per second. The entire frequency range, 10 to 55 to 10 cps, shall be traversed in one minute. Capacitors shall be vibrated for 1½ hours with the direction of motion being parallel to the axis of the capacitor. The capacitors shall then be placed so that the direction of motion is perpendicular to the axis and the vibration continued for 1½ hours. During the last ½ hour of the test, the capacitor shall be connected to a bridge and observed for a 3 minute period. A capacitor failing the vibration test is defined as one failing to meet the requirements of paragraph 9.1.

9.1 There shall be no evidence of loosening of the capacitor element within the container, when shaken by hand following the test. There shall be no indication of intermittent contact during the 3 minute observation period. Capacitors shall not be open or shorted.

10. **Marking**
Capacitors will have the following minimum marking:

Manufacturer's Name And/Or Symbol
Manufacturer's Part Number
Capacitance (Min-Max Mfd)
Rated Voltage
Rated Frequency
EIA Source and Date Code

Application Guidelines

The Philips Components AC Motor Start capacitors are non-polar aluminum electrolytic capacitors designed for intermittent AC duty; more specifically, the starting of small AC motors. They are not suitable for most DC or continuous AC applications.

1. **Duty Cycle**
The duty cycle of an AC Motor Start capacitor may be determined by dividing the capacitor's on-time (energized time) by the sum of its on-time (energized time) and its off-time (de-energized time). For a given AC Motor Start capacitor, operating at a given voltage and ambient temperature; the time-averaged power dissipated by the capacitor, the internal operating temperature of the capacitor and, therefore, the life expectancy of the capacitor are all directly proportional to the capacitor's duty cycle.

1.1 Normal capacitor life may be realized (assuming voltage and temperature limits are not exceeded) when the on-time of a capacitor does not exceed 3 seconds and its duty cycle does not exceed 0.0167. Example: Twenty (20) three (3) second starts per hour yield a duty cycle of 0.0167 and does not exceed the three (3) second on-time limit.

1.2 Longer than 3 second on-times are not recommended as they will cause the capacitor's life to be shortened. Should they be unavoidable, there are certain things that can be done to minimize the degradation of the capacitor's life expectancy. For on-times up to 6 seconds:

- Reduce the duty cycle by increasing the off-time
- Reduce the ambient temperature
- Provide forced air cooling
- Use a capacitor with a higher voltage rating
- Series two capacitors each having twice the mfd value of the original.

2. **Frequency**
These capacitors are designed for and are tested at 60 Hz. They are, however, suitable for use from 50 to 60 Hz.

3. **Voltage**
Rated voltage and overvoltage (proof test) have been covered in the PERFORMANCE SPECIFICATIONS section and will not be reiterated here. However, there is a third voltage that should be considered in the application of AC Motor Start capacitors.

During the start cycle of a normal capacitor motor, the voltage impressed across the AC motor start capacitor does not remain constant. It should start close to the rated voltage, dip slightly and then begin to increase as the motor's RPM increases. Should the start switch fail to open, it is possible for the capacitor's voltage to increase to as much as 2 to 3 times the capacitor's rated voltage.

3.1 Normal capacitor life may be realized (assuming temperature and duty cycle limits are not exceeded) when, during the start cycle, the voltage impressed across the capacitor does not exceed 125% of its rated voltage.

4. **Temperature**
The storage and operating temperatures have been covered in the PERFORMANCE SPECIFICATIONS section. There has been some misunderstanding about the −40°C lower limit. As the temperature decreases from room temperature, capacitance starts to fall and % power factor (measurement of losses) starts to rise. Either one of these effects will cause a decrease in a motor's starting torque. The effects are such that below −40°C, a stalled rotor condition could occur. However, because the losses are so high, the internal capacitor temperature will rise rather quickly, thus restoring normal start torque. The total effect may just be a delay in the motor reaching switch out speed.

5. **Shelf Life**
The normal shelf life expectancy for these capacitors is typically in excess of 5 years when stored in ambient temperatures not exceeding 40°C.

6. **Resistors**
Some specialized applications require that the motor start capacitor be discharged prior to the closing of the start switch. This minimized shock hazard, Switch Bounce noise, and peak contact currents. The resistor used to discharge the capacitor should be large enough so as not to significantly increase the power factor and small enough to insure discharging the capacitor within the time required. Normally, a 15K ohm ±20% 2-watt resistor is used. Consult factory for this option.

7. **Mounting**
Vertical mounting of the capacitor with the terminals up is recommended; however, horizontal mounting with the pressure relief vent up is acceptable. Vertical mounting with terminals down or horizontal mounting with a relief vent down is not recommended as they may reduce capacitor life and could impair the operation of the pressure relief vent.

8. **Cleaning Solvents**
Recommended cleaning solvents are those free of halogens or halogen groups such as ethyl alcohol, butyl alcohol, methyl alcohol, propyl alcohol and deionized or distilled water.
Solvents that are NOT recommended are halogenated hydrocarbon solvents such as Freon TF®, Freon TMC®, carbon tetrachloride, chloroform, trichloroethylene, trichloroethane, and methylene chloride.

9. **Safety**
The watt-second capability of these capacitors is high enough that precautions should be taken during the testing and application of these devices. Normally, the DC series resistance of the main and auxiliary windings are such that the capacitor is completely discharged prior to the motor coming to a complete stop. However, if this is not the case, or if this is deemed inadequate, discharge resistors are available from the factory.

9.1 **Misapplication, such as exceeding design limits or applying continuous AC voltage, may result in destruction or explosion of capacitors.**

9.2 **Care should be exercised in the mounting of these capacitors to insure minimal damage in the event of an explosion.**

10. **General**
In the event that application requirements exceed the parameters expressed herein, it is often possible to use a standard capacitor, providing certain "tradeoffs" are acceptable. It is also possible that special designs and/or manufacturing techniques not normally included, could be applied to meet a special situation.

10.1 When consulting the factory about a special application or an application problem, the following minimum information should be available:

a. Capacitor nameplate information; MFD value, voltage, etc.
b. Case size (diameter × length)
c. Capacitor's worst case duty cycle
d. Maximum switch out voltage
e. Maximum ambient temperature
f. Any special or unusual application characteristic

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Performance Specifications

1. TEMPERATURE

These capacitors are designed to operate without derating within the temperature ranges indicated in the following table. Under non-operating conditions they may be subjected to temperatures in storage, or in transient at altitudes up to the indicated maximum, as shown under NON-OPERATING in TABLE 1, without permanent damage.

Where a nominal temperature is indicated for performing standard measurements or tests in this catalog, the temperature tolerance will be ±3°C unless otherwise specified.

Table 1 Ambient Temperature Range

Capacitor Series	Operating Temp. (°C)	Non-Operating	
		Temp. (°C)	Max. Altitude (ft.)
3186	−40 to +85	−55 to +85	80,000
3188	−40 to +105	−55 to +85	80,000
3191	−40 to +85	−55 to +85	200,000
3407	−40 to +85	−55 to +85	80,000
3408	−40 to +105	−55 to +85	80,000
3487	−40 to +85	−55 to +85	80,000
3488	−40 to +105	−55 to +85	80,000

Low Temperature Performance: To determine the typical capacitance and impedance at −40°C and at a frequency of 120 Hz multiply the 25°C measurement times the appropriate multiplier below.

Series	Rated DC Voltalge	% of 25°C Cap	25°C Impedance Multiplier
3191	0-9	50	5.5
	10-75	60	4.5
	76-250	85	2.0
3186, 3188	0-75	35	9.0
3487, 3488	76-250	70	4.0
	251-450	30	6.0
3407, 3408	160-250	—	12
3407	251-450	—	24

2. DC WORKING VOLTAGE

The DC working voltage is the maximum permissible operating voltage (DC volts + peak ripple voltage) for continuous operations at maximum rated temperature.

3. SURGE VOLTAGE

The surge voltage is the maximum instantaneous voltage to which the capacitor should be subjected (DC voltage + ripple voltage + transient voltage). It must not exceed the value specified in the Standard Rating tables.

SURGE TEST REQUIREMENTS:

Capacitors shall be connected in series with a resistor of the value indicated:

Capacitance (μF)	Resistor (ohms)
0-2500	1000
2501-25000	100
25001-250000	10
250001-UP	3

The series combination is then subjected to rated surge voltage at the conditions specified in TABLE 2. The capacitor is allowed to discharge through the resistor. Leakage current, when measured as described in paragraph 6 below, not sooner than four hours after completion of the test, shall not exceed the initial leakage current limit. There shall be no leaking of the electrolyte and no mechanical damage.

Table 2

Product Type	Temperature °C	No. Cycles	Duty Sec. On	Cycle Sec. Off
3487	25	144	30	570
3488	25	144	30	570
3186	25	144	30	570
3188	25	144	30	570
3191	85	1000	30	330
3407	25	1000	30	330
3408	25	1000	30	330

4. CAPACITANCE

Capacitance shall be measured on a capacitance bridge having a miximum RMS signal voltage of 1 volt at 120 Hz. Capacitance shall be within the tolerance specified in TABLE 3 when measured at 25°C.

Table 3

Capacitor Series	DC Working Voltage	Tolerance (%)
3487	6.3-450	−20 +20
3488	6.3-250	−20 +20
3186	5-100	−10 +75
	101-450	−10 +50
3188	5-75	−10 +75
	76-400	−10 +50
3191	5-55	−20 +20
3407	160-450	−20 +20
3408	160-250	−20 +20

5. EQUIVALENT SERIES RESISTANCE (ESR)

The ESR shall be measured by the bridge method at the frequency specified in the rating tables and 25°C. It shall be within the limits shown in the rating tables.

6. DC LEAKAGE CURRENT TEST

Preconditioning: In the period 24 to 48 hours prior to test, rated working voltage shall be applied to the capacitor for the charge times shown in TABLE 4.

Measurement: The leakage current shall be measured at 25 C. Voltage shall be applied to the capacitor through a current-limiting resistor, and the measurement shall be made five minutes after the capacitor reaches rated voltage. Leakage current (I_L shall not exceed the value calculated from the equation shown in TABLE 4. In no case, however, shall I_L exceed the maximum value shown.

Table 4 Leakage Current Formulas

Time Series	Pre-Conditioning Equation (minutes)	Equation I-MA	Max. Value (MA)
3487	30	$.006\sqrt{CV}$	6
3488 (CV≤250,000)	30	6×10^{-6} CV	4
(CV>250,000)	30	$.003\sqrt{CV}$	4
3186	30	$.006\sqrt{CV}$	6
3188 (CV≤250,000)	30	6×10^{-6} CV	4
(CV>250,000)	30	$.003\sqrt{CV}$	4
3191	15	$.0015\sqrt{CV}$	N/A
3407	30	$.003\sqrt{CV}$	N/A
3408	30	$.003\sqrt{CV}$	N/A

7. LIFE TEST

Capacitors to be tested will first be measured for DC Leakage current capacitance & ESR at 25°C. The capacitors shall then be placed in a circulating-air oven and kept at the ambient temperature indicated in TABLE 5, Column A. Spacing between capacitors shall be at least 1″, and capacitors must not be subjected to direct radiation from heating elements. Circulation of air shall be sufficient to keep the temperature within the limits shown when measured on the surface of the capacitors

Rated DC voltage or rated DC voltage with ripple current shall be applied to the capacitors as indicated in Table 5, Column C, for the period of time shown in Column B. The capacitors shall then be returned to a temperature of 25°C for at least 24 hours.

Upon completion of the test, the capacitors shall meet the following requirement:

Capacitance, when measured per paragraph 4, shall not be less than the value indicated in TABLE 5, Column D.

Equivalent Series Resistance (ESR) when measured per paragraph 5, shall not be greater than the value indicated in TABLE 5, Column E.

Leakage Current, when measured and determined per paragraph 6, shall not exceed the value indicated in TABLE 5, Column F.

There shall be no evidence of mechanical damage or excessive electrolyte leakage.

8. SHELF TEST

Capacitors to be tested shall first be measured for DC leakage current, capacitance and ESR at 25°C. The capacitors shall then be placed in a circulating-air oven and kept at the ambient temperature indicated in TABLE 6, Column A. Spacing between capacitors shall be at least 1″, and capacitors must not be subjected to a direct radiation from heating elements. Circulation of air shall be sufficient to keep the temperature within the limits shown, when measured on the surface of the capacitor.

The capacitors shall be kept in this environment for the period shown in TABLE 6, Column B, with no voltage applied. They shall then be allowed to cool in an ambient temperature of 25°C for at least the period of time indicated in Column C.

Upon completion of the test, the capacitors shall meet the following requirements:

Leakage Current, when measured without preconditioning per paragraph 6, shall not exceed the value shown in TABLE 6, colulmn F.

Capacitance and ESR as indicated in TABLE 6, Columns D & E respectively.

There shall be no evidence of mechanical damage or excessive electrolyte leakage.

Shelf Life. The normal shelf life expectancy for these capacitors when stored at ambient temperatures of 40°C or below is indicated in TABLE 6, Column G. When stored for longer periods, and/or at higher temperatures, their leakage current should be checked at room temperature in accordance with the original requirement, before placing the capacitors in service. If the leakage current exceeds the value calculated from the formulas in TABLE 4, refer to Technical Note on Reform Procedures.

9. VIBRATION

Series 3186, 3188, 3191, 3487, 3488
Capacitors shall be clamped rigidly to a vibration platform and subjected to a simple harmonic motion having a maximum peak-to-peak amplitude of .06 inches and a maximum acceleration of 10g. The entire frequency of vibration shall be varied linearly between 10 and 55 cycles per second. The frequency range, 10 to 55 to 10 cps, shall be traversed in one minute.

Capacitors shall be vibrated for 1½ hours with the direction of motion being parallel to the axis of the capacitor. The capacitor shall then be placed so that the direction of motion is perpendicular to the axis and the vibration continued for a additional 1½ hours.

During the last ½ hour of the test, the capacitor shall be connected to a bridge and observed for a 3-minute period.

There shall be no evidence of loosening of the capacitor element within the container, when shaken by hand, following the test. There shall be no indication of intermittent electrical contact during the 3-minute observation period. Capacitors shall not be open or shorted.

HIGH VIBRATION

UPON SPECIAL REQUEST capacitors are available to meet the following test. Capacitors shall be clamped rigidly to a vibration platform and subjected to a simple harmonic motion having a maximum peak-to-peak amplitude of .06 inches and a maximum acceleration of 20g. The frequency of vibration shall be varied logarithmically between 10 and 2000 cycles per second. The entire frequency range, 10 to 2000 to 10 cps, shall be traversed in 20 minutes. This cyle may be repeated two times in each of three mutually perpendicular directions, the first being such that the direction of motion is parallel to the axis of their containers.

At some time during the last half hour of the test each component on test shall be connected for capacitance measurement and its capacitance shall be observed for a period of approximately three (3) minutes.

There shall be no evidence of loosening of the capacitor element within the container as evidence by shaking. There shall be no indication of intermittent connection during the three (3) minute observation period. Capacitors shall not be opened or shorted.

10. CONTAINER SEAL TEST

SERIES 3186, 3188, 3191, 3487, 3488,: Following the Vibration test of paragraph 9, capacitors shall be subjected to two successive temperature cycles in circulating air. Each cycle will be as follows:

A 85°C-30 minutes
B 25°C-30 minutes
C −40°C-30 minutes
D 25°C-30 minutes

Following the second cycle, the capacitors shall be placed in 90-95°C water for 5 minutes. A failure is defined as a unit exhibiting a continuous chain of bubbles when immersed.

Table 5 Life Test

Series	A Ambient Temp. (°C ±3°C)	B Test Period Hours (±8 hrs.)	C Test Conditions	D Cap. Min. (%)*	E tan d or ESR Max. (%)*	F Leakage Current Max. (%)**
3186, 3487,	85 85 95	2000 1000 1000	DC Voltage DC Voltage & Ripple DC Voltage	90	175	100
3188, 3488	85 85 105	4000 2000 2000	DC Voltage DC Voltage & Ripple DC Voltage	85	175	100
3191	85 85 100	3000 1500 1500	DC Voltage DC Voltage & Ripple DC Voltage	85	175	100
3407 3408	85 105	2000 2000	DC Voltage & Ripple	80 80	200 200	100 100

*Referred to initial measured value
**Referred to initial specification limit

Table 6 Shelf Test

Capacitor Series	A Ambient Temp. (°C ±3°C)	B Test Period (hrs.)	C Cooling Period @ 25°CC (hrs.)	D Cap. Min. (%)*	E tan d or ESR Max. (%)**	F Leakage Current (%)*	G Shelf Life Expectancy (years)
3186, 3487,	85	100±4	24	100	100	200	3
3188, 3488,	85	250±4	16	100	100	100	4
3191	85	100±4	16	100	100	200	3
3407	85	1000	24	100	100	200	3
3408	85	1000	24	100	100	200	3

*Referred to original specification
**Referred to initial specification

Technical Notes

1. CAPACITOR LIFE PREDICTION GUIDELINES

The following equations and tables can be used to predict the life of aluminum electrolytic capacitors at derated voltages and temperatures. Failures are defined as parameter drift beyond the limits outlined in the life test section of the Performance Specifications.

Based on DC aluminum electrolytic capacitor tests, the inherent relationships between temperature, voltage and life were established. A failure rate for each product was established from testing at maximum rated conditions. From this failure rate a base lifetime was established.

The expected life for each product type is determined by computing the capacitor hot-spot temperature [equation (1)] and the ratio of use voltage to rated voltage. From this, the base life multiplier can be found in the appropriate table. The multiplier times the base life (found in Table 1) yields the expected life.

The computation of expected life assumes a constant or decreasing failure rate and that the wearout portion of the product life has not been reached. The expected life is the statistical time required to generate one failure in 25 units based on a 60% confidence level.

Multipliers resulting in expected lifetimes in excess of 10 years may not be valid due to secondary failure modes not considered in the construction of these tables.

CALCULATION OF CORE TEMPERATURE

(1) Core Temp = Ambient + $\frac{I^2 \times E.S.R.}{K \times Area}$

$$K = .006 \frac{\frac{\text{WATTS}}{\text{sq. inch}}}{°C}$$

AREA = Surface Area of Can =

$$\pi \times D_{IA} \times \left(L_E + \left(\frac{D_{IA}}{2}\right)\right)$$

I = Ripple Current (Amps)
AMB = Ambient Temperature (°C)
ESR = Equivalent Series Resistance (ohms)

*Based on free convection in still air. For values of K in forced air see Application guidelines sec 2.3

Table 1 Table Base Life

Type	Load Life Hours	Ambient Temp. C°	Design Core Temp. °C	Life Multiplier Table
3186	1000	85	95	2
3188	2000	85	105	3
3191	1500	85	100	4
3407	2000	85	95	2
3408	2000	105	110	3
3487	1000	85	95	2
3488	2000	85	105	3

Table 2 Life Multiplier

Core Temp.	% Rated Voltage 75	80	85	90	95	100
95	2.6	2.2	1.8	1.5	1.2	1.0
94	2.7	2.2	1.8	1.6	1.3	1.1
93	2.9	2.4	2.0	1.6	1.3	1.2
92	3.3	2.8	2.4	1.9	1.5	1.2
91	3.6	2.9	2.4	2.0	1.6	1.3
90	3.8	3.2	2.6	2.2	1.8	1.4
89	4.2	3.4	2.8	2.3	1.9	1.5
88	4.2	3.5	2.9	2.4	1.9	1.6
87	4.6	3.9	3.2	2.6	2.1	1.7
86	5.0	4.2	3.4	2.9	2.4	1.9
85	5.3	4.4	3.6	3.0	2.4	2.0
84	5.8	4.9	4.0	3.2	2.6	2.1
83	6.2	5.2	4.2	3.5	2.8	2.3
82	6.6	5.5	4.4	3.7	3.0	2.5
81	7.3	6.1	5.0	4.1	3.3	2.6
80	7.9	6.5	5.4	4.4	3.5	2.8
79	8.3	6.8	5.6	4.5	3.7	3.0
78	9.1	7.5	6.1	5.0	4.0	3.3
77	9.6	7.9	6.4	5.3	4.2	3.5
76	10.5	8.6	7.1	5.7	4.7	3.7
75	11.3	9.2	7.5	6.1	5.0	4.0
74	12.2	10.0	8.1	6.6	5.3	4.3
73	12.9	10.6	8.6	7.0	5.6	4.6
72	14.1	11.4	9.4	7.6	6.1	4.9
71	15.1	12.4	10.0	8.1	6.6	5.3
70	16.3	13.3	10.6	8.8	7.1	5.7
69	17.3	14.2	11.5	9.3	7.5	6.1
68	18.8	15.4	12.4	10.1	8.1	6.5
67	20.0	16.3	13.2	10.7	8.6	7.0
66	21.7	17.6	14.3	11.6	9.3	7.5
65	23.3	18.9	15.3	12.4	10.0	8.0
64	25.2	20.4	16.5	13.3	10.7	8.6
63	27.0	21.9	17.6	14.2	11.4	9.2
62	29.1	23.5	19.0	15.3	12.4	9.8
61	31.2	25.3	20.4	16.4	13.2	10.6
60	33.4	26.9	21.7	17.5	14.1	11.3

Table 2 Life Multiplier (*continued*)

Core Temp.	% Rated Voltage 75	80	85	90	95	100
59	35.9	29.0	23.3	18.7	15.1	12.1
58	38.8	31.3	25.2	20.3	16.2	13.0
57	41.5	33.5	26.9	21.6	17.3	13.9
56	44.7	36.0	28.9	23.2	18.6	14.9
55	48.0	38.6	31.0	24.9	19.9	16.0
54	51.5	41.4	33.4	26.6	21.3	17.2
53	55.6	44.6	35.8	28.7	23.0	18.4
52	59.6	47.9	38.4	30.7	24.6	19.7
51	64.1	51.3	41.1	32.9	26.4	21.1
50	68.8	55.2	44.2	35.4	28.3	22.6
49	74.0	59.2	47.4	37.9	30.3	24.2
48	79.6	63.7	51.0	40.7	32.5	26.0
47	85.6	68.3	54.6	43.7	34.9	27.9
46	91.8	73.3	58.5	46.8	37.4	29.9
45	98.5	78.6	62.8	50.2	40.0	32.0
44	105.9	84.4	67.3	53.8	42.9	34.3
43	113.9	90.8	72.4	57.7	46.1	36.8
42	122.3	97.4	77.6	61.9	49.4	39.4
41	131.3	104.5	83.3	66.3	52.9	42.2
40	141.1	112.2	89.3	71.2	56.8	45.3
39	151.3	120.4	95.7	76.3	60.8	48.5
38	162.7	129.2	102.8	81.9	65.2	52.0
37	174.4	138.7	110.3	87.8	69.9	55.7
36	187.6	148.9	118.3	94.1	75.0	59.7
35	201.4	159.7	126.8	100.9	80.3	64.0
34	216.2	171.4	136.1	108.2	86.1	68.6
33	232.5	184.2	146.1	116.1	92.4	73.5
32	249.4	197.5	156.7	124.4	99.0	78.8
31	267.9	212.0	168.1	133.5	106.1	84.5
30	287.5	227.4	180.2	143.1	113.8	90.5
29	308.6	244.0	193.3	153.4	121.9	97.0
28	331.3	261.8	207.3	164.5	130.7	104.0
27	355.6	280.8	222.3	176.3	140.1	111.4
26	382.0	301.6	238.6	189.2	150.3	119.4
25	409.9	323.4	255.8	202.8	161.0	128.0

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Table 3 Life Multiplier

Core Temp.	% Rated Voltage					
	75	80	85	90	95	100
105	1.80	1.60	1.40	1.30	1.10	1.00
104	1.79	1.60	1.51	1.32	1.13	1.04
103	1.88	1.70	1.52	1.34	1.16	1.07
102	1.96	1.79	1.54	1.37	1.19	1.11
101	2.05	1.81	1.64	1.48	1.31	1.15
100	2.14	1.90	1.74	1.51	1.35	1.19
99	2.23	2.00	1.77	16.2	1.39	1.23
98	2.40	2.10	1.87	1.65	1.50	1.27
97	2.36	21.5	1.88	1.67	1.46	1.32
96	2.53	2.32	2.05	1.78	1.57	1.37
95	2.64	2.31	2.06	1.80	1.61	1.41
94	2.80	2.48	2.23	1.97	1.72	1.46
93	2.91	2.61	2.30	2.00	1.76	1.52
92	3.02	2.67	2.38	2.09	1.80	1.57
91	3.19	2.80	2.46	2.18	1.90	1.62
90	3.21	2.84	2.52	2.21	1.94	1.68
89	3.43	3.02	2.66	2.30	2.00	1.74
88	3.51	3.12	2.73	2.39	2.09	1.80
87	3.69	3.22	2.85	2.47	2.15	1.87
86	3.82	3.37	2.97	2.56	2.25	1.93
85	4.00	3.52	3.09	2.70	2.35	2.00
84	4.29	3.77	3.30	2.87	2.49	2.14
83	4.64	4.04	3.53	3.06	2.64	2.30
82	5.01	4.37	3.82	3.31	2.84	2.46
81	5.45	4.77	4.13	3.58	3.11	2.64
80	5.87	5.11	4.43	3.84	3.29	2.83
79	6.32	5.52	4.80	4.13	3.54	3.03
78	6.79	5.91	5.12	4.42	3.79	3.25
77	7.30	6.34	5.51	4.73	4.06	3.48
76	7.92	6.88	5.97	5.14	4.40	3.73
75	8.54	7.42	6.39	5.48	4.70	4.00
74	9.15	7.92	6.86	5.88	5.02	4.29
73	9.88	8.54	7.36	6.30	5.41	4.59
72	10.6	9.16	7.87	6.74	5.77	4.92
71	11.5	9.91	8.50	7.29	6.20	5.28
70	12.4	10.7	9.15	7.82	6.66	5.66
69	13.3	11.4	9.81	8.38	7.14	6.06
68	14.3	12.3	10.5	8.99	7.65	6.50
67	15.5	13.3	11.4	9.68	8.23	6.96
66	16.7	14.3	12.2	10.4	8.85	7.46
65	17.9	15.3	13.1	11.1	9.45	8.00

Table 3 Life Multiplier (*continued*)

Core Temp.	% Rated Voltage					
	75	80	85	90	95	100
64	19.4	16.6	14.1	12.1	10.1	8.57
63	20.8	17.8	15.1	12.8	10.9	9.19
62	22.4	19.1	16.2	13.8	11.7	9.85
61	24.2	20.6	17.5	14.8	12.5	10.6
60	26.0	22.1	18.8	15.9	13.4	11.3
59	28.1	23.8	20.2	17.1	14.4	12.1
58	30.2	25.6	21.7	18.3	15.4	13.0
57	32.5	27.5	23.3	19.6	16.6	13.9
56	35.0	29.6	25.0	21.1	17.7	14.9
55	37.7	31.8	26.9	22.7	19.1	16.0
54	40.6	34.3	28.9	24.3	20.4	17.1
53	43.7	36.8	31.0	26.0	21.9	18.4
52	47.0	39.5	33.3	27.9	23.5	19.7
51	50.6	42.6	35.7	30.0	25.2	21.1
50	54.4	45.7	38.4	32.2	27.0	22.6
49	58.7	49.2	41.3	34.6	29.0	24.3
48	63.2	52.9	44.3	37.1	31.1	26.0
47	67.9	56.9	47.6	39.8	33.3	27.9
46	73.1	61.1	51.1	42.7	35.7	29.9
45	78.7	65.7	54.9	45.9	38.3	32.0
44	84.6	70.6	58.9	49.2	41.1	34.3
43	91.1	75.9	63.2	52.8	44.0	36.8
42	98.0	81.6	68.0	56.6	47.2	39.4
41	105.5	87.7	73.0	60.7	50.6	42.2
40	113.4	94.2	78.3	65.2	54.3	45.3
39	122.1	101.3	84.1	69.9	58.2	48.5
38	131.3	108.8	90.3	75.0	62.4	52.0
37	141.3	117.0	97.0	80.5	67.0	55.7
36	152.0	125.7	104.1	86.4	71.8	59.7
35	163.4	135.0	111.8	92.7	77.0	64.0
34	175.8	145.1	120.0	99.4	82.5	68.6
33	189.9	155.8	128.8	106.7	88.5	73.5
32	203.3	167.4	138.3	114.4	94.9	78.8
31	218.6	179.9	148.5	122.8	101.7	84.4
30	235.1	193.3	159.4	131.7	109.1	90.5
29	252.7	207.6	171.0	141.3	117.0	97.0
28	271.7	223.0	183.6	151.6	125.4	104.0
27	292.1	239.5	197.1	162.6	134.5	111.4
26	314.0	257.2	211.5	174.4	144.2	119.4
25	337.6	276.3	227.0	187.1	154.6	128.0

Table 4 Life Multiplier

Core Temp.	% Rated Voltage					
	75	80	85	90	95	100
100	2.50	2.10	1.80	1.50	1.20	1.00
99	2.54	2.16	1.79	1.51	1.22	1.04
98	2.59	2.23	1.88	1.52	1.25	1.07
97	2.96	2.50	2.03	1.66	1.39	1.11
96	3.00	2.56	2.12	1.77	1.41	1.15
95	3.14	2.63	2.21	1.78	1.53	1.19
94	3.28	2.79	2.30	1.89	1.56	1.23
93	3.22	2.70	2.25	1.87	1.50	1.27
92	3.45	2.86	2.35	1.98	1.61	1.32
91	3.59	3.02	2.52	2.08	1.73	1.37
90	3.64	3.03	2.56	2.09	1.68	1.41
89	3.93	3.26	2.73	2.20	1.80	1.46
88	3.98	3.35	2.78	2.27	1.83	1.52
87	4.16	3.44	2.84	2.35	1.93	1.57
86	4.29	3.54	2.96	2.44	1.94	1.62
85	5.33	4.40	3.67	3.00	2.40	2.00
84	5.76	4.76	3.95	3.22	2.61	2.14
83	6.28	5.20	4.26	3.51	2.84	2.30
82	6.65	5.52	4.53	3.73	2.99	2.46
81	7.31	6.02	4.94	4.06	3.32	2.64
80	7.88	6.46	5.32	4.31	3.50	2.83
79	8.30	6.85	5.60	4.55	3.69	3.03
78	9.02	7.43	6.10	4.97	4.04	3.25
77	9.66	7.95	6.50	5.26	4.27	3.48
76	10.5	8.66	7.06	5.73	4.67	3.73
75	11.2	9.18	7.48	6.10	4.92	4.00
74	12.1	9.96	8.11	6.60	5.34	4.29
73	13.0	10.6	8.66	7.02	5.71	4.59
72	14.1	11.5	9.32	7.55	6.11	4.92
71	15.0	12.3	9.97	8.08	6.52	5.28
70	16.1	13.2	10.7	8.65	7.02	5.66
69	17.5	14.2	11.5	9.32	7.56	6.06
68	18.7	15.3	12.3	10.0	8.06	6.50
67	20.2	16.5	13.3	10.7	8.66	6.96
66	21.7	17.7	14.3	11.6	9.28	7.46
65	23.3	12.5	15.3	12.3	9.94	8.00
64	25.0	20.3	16.4	13.2	10.6	8.57
63	26.9	21.8	17.6	14.2	11.4	9.19

Table 4 Life Multiplier (*continued*)

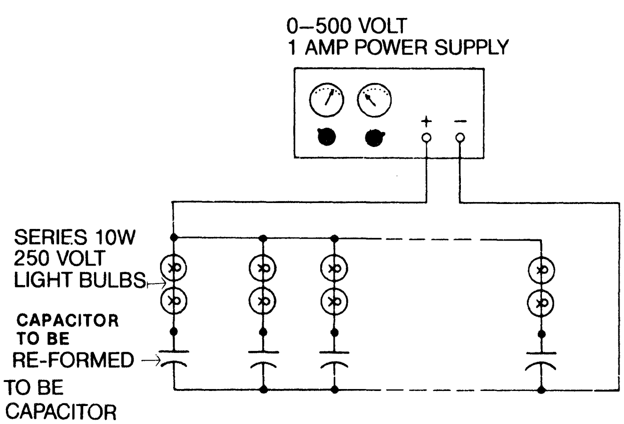
Core Temp.	% Rated Voltage					
	75	80	85	90	95	100
62	29.0	23.5	18.9	15.3	12.3	9.85
61	31.2	25.2	20.3	16.4	13.2	10.6
60	33.6	27.1	21.9	17.6	14.1	11.3
59	36.1	29.1	23.5	18.9	15.1	12.1
58	38.8	31.2	25.2	20.2	16.2	13.0
57	41.7	33.5	27.0	21.7	17.4	13.9
56	44.8	36.0	29.0	23.2	18.6	14.9
55	48.1	38.7	31.1	24.9	20.0	16.0
54	51.6	41.5	33.3	26.7	21.4	17.1
53	55.6	44.6	35.8	28.7	23.0	18.4
52	59.6	47.8	38.3	30.7	24.6	19.7
51	64.2	51.5	41.2	33.0	26.4	21.1
50	68.8	55.2	44.2	35.3	28.3	22.6
49	74.0	59.2	47.4	37.9	30.3	24.3
48	79.6	63.6	50.8	40.7	32.5	26.0
47	85.5	68.3	54.6	43.6	34.9	27.9
46	91.9	73.4	58.6	46.8	37.4	29.9
45	98.6	78.7	62.9	50.2	40.0	32.0
44	106.0	84.5	67.5	53.8	43.0	34.3
43	113.8	90.7	72.3	57.7	46.0	36.0
42	122.2	97.3	77.5	61.9	49.4	39.4
41	131.4	104.6	83.3	66.4	52.9	42.2
40	141.0	112.1	89.3	71.1	56.7	45.3
39	151.5	120.4	95.9	76.4	60.9	48.5
38	162.6	129.2	102.8	81.8	65.2	52.0
37	174.8	138.8	110.4	87.8	69.9	55.7
36	187.7	149.0	118.4	94.2	75.0	59.7
35	201.5	159.8	126.9	100.9	80.4	64.0
34	216.3	171.5	136.1	108.2	86.1	68.6
33	232.3	184.0	146.0	116.1	92.3	73.5
32	249.4	197.5	156.7	124.4	99.0	78.8
31	267.9	212.0	168.1	133.5	106.1	84.4
30	287.5	227.4	180.3	143.1	113.8	90.5
29	308.7	244.1	193.3	153.4	122.0	97.0
28	296.1	233.9	185.3	147.0	116.8	104.0
27	355.7	280.9	222.4	176.4	140.1	111.4
26	381.8	301.4	238.5	189.1	150.1	119.4
25	409.9	323.4	255.8	202.8	161.0	128.0

2. FIELD RE-FORM PROCEDURE

DC aluminum electrolytic capacitors require reforming when the leakage current exceeds the value calculated from the leakage current fromulas in paragraph 3 below. The procedure for reforming in the field is as follows:

1. Preheat capacitors to 85°C ±5°C for 4 hours ±.5 hour.
2. Remove capacitors from oven and apply 110% rated voltage in a room temperature ambient (25°C ±3°C) as per the diagram below. Remove and discard any units that are shorted or appear to draw a constant or increasing amount of current.
3. Remove units from re-form set-up after the *average* unit current drawn from the power supply is ¼ of the leakage requirement for the unit type involved.
4. Condition units for 24 hours ±5 hours in a room-temperature ambient with no voltage applied. Then measure leakage current as outlined in Performance Specifications paragraph 6. Repeat steps 1 through 4 for units that do not meet this limit. Discard any units that have ruptured vent plugs or have evidence of leaking electrolyte.

When units are re-formed by this procedure, they will have a shelf life of approximately one year, provided the storage ambient does not exceed 40°C.



3. CAPACITOR SHELF-CHARACTERISTICS

The graphs on the next page can be used to predict the shelf life of aluminum electrolytic capacitors stored in various ambient temperatures. The Specification Limit Line on the left of the graph indicates the length of time, at various temperatures for which the capacitors are expected to meet the leakage current limits calculated from the formulas shown below. The Practical Limit Line on the right of the graph defines the length of storage for which a user should expect acceptable performance from the capacitor in normal applications.

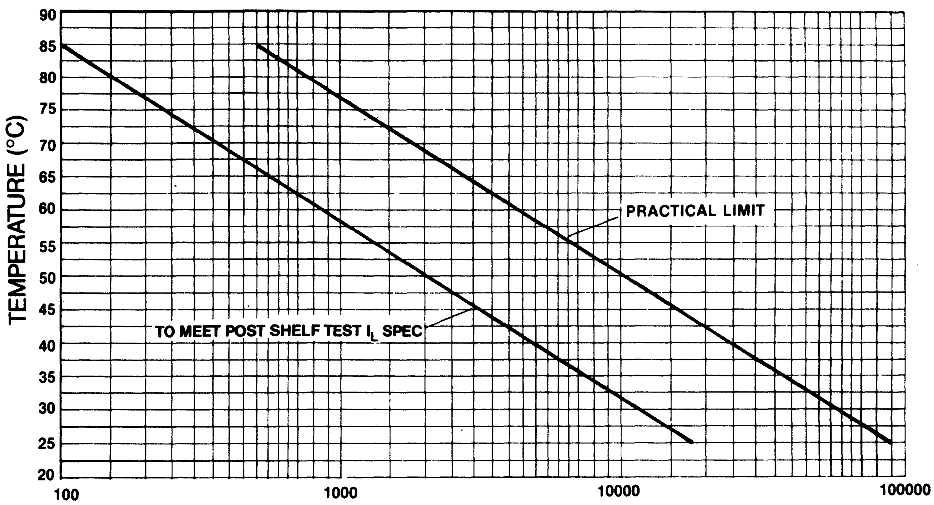
Capacitors that are to be used at operating temperatures which are at least 25°C less than the maximum operating temperature and have been in storage for a period longer than the Practical Limit should have their leakage current checked. Any unit whose leakage current exceeds the value calculated from the formulas shown below should be re-formed.

Capacitors that draw a constant or increasing amount of leakage should also be re-formed.

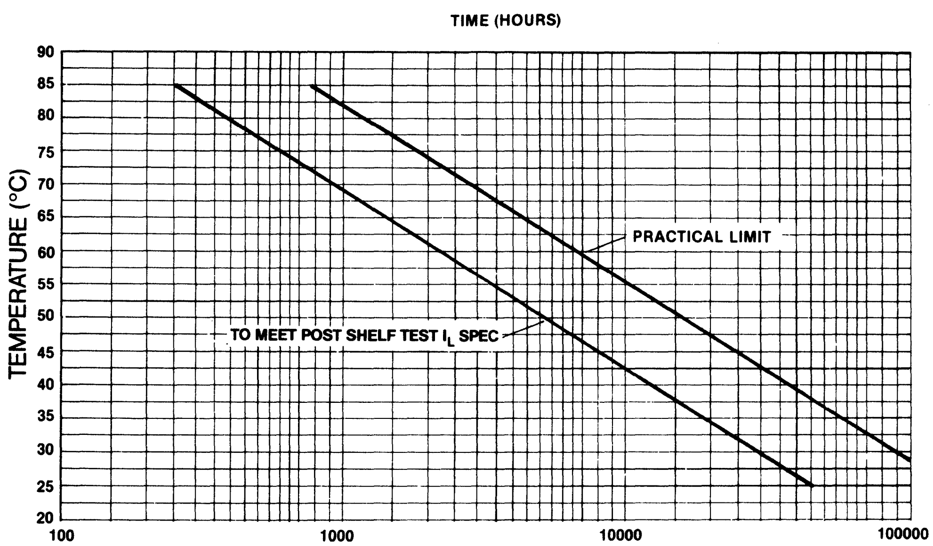
Leakage current after pre-conditioning or re-form is measured after five minutes of voltage application. The voltage is applied to the capacitor through a series resistor with a value such that the rated voltage will appear on the capacitor terminals within one minute.

Table 5 Leakage Current Formulas

Time Series	Pre-conditioning Equation (minutes)	Equation I-MA	Max. Value (MA)
3487	30	$.006\sqrt{CV}$	6
3488 (CV ≤ 250,000)	30	6×10^{-6} CV	4
(CV > 250,000)	30	$.003\sqrt{CV}$	4
3186	30	$.006\sqrt{CV}$	6
3188 (CV ≤ 250,000)	30	6×10^{-6} CV	4
(CV > 250,000)	30	$.003\sqrt{CV}$	4
3191	15	$.0015\sqrt{CV}$	N/A
3407	30	$.003\sqrt{CV}$	N/A
3408	30	$.003\sqrt{CV}$	N/A



3186, 3191, 3487 Shelf characteristics



3188, 3488 Shelf characteristics

Application Guidelines—Computer Grade & Snap-in Series 3000

1. TYPICAL ESR AS A FUNCTION OF FREQUENCY.

Figures 1, 2, and 3 represent the ratio of ESR change from 120 Hz to 100KHz. They are categorized into three voltage ranges and are categorized into three voltage ranges and are valid for all the computer grade and snap-in type units. To obtain the ESR of a unit at a frequency above 120Hz, find the ratio of change from the appropriate curve. Multiply the listed 120 Hz ESR of the subject unit by the ratio, the result is the ESR at the desired frequency.

Fig. 1 HI FREQ. ESR MULTIPLIER 0-75 VOLT

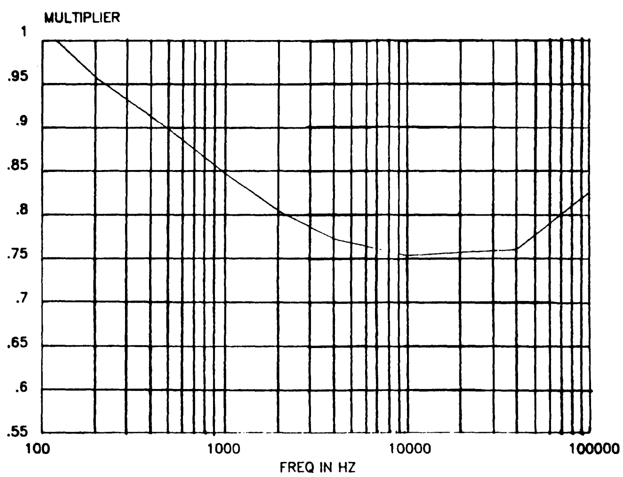


Fig. 2 HI FREQ. ESR MULTIPLIER 76-250 VOLT

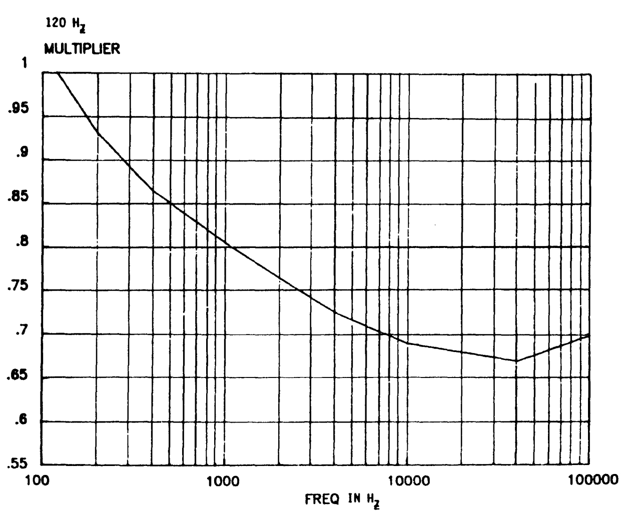
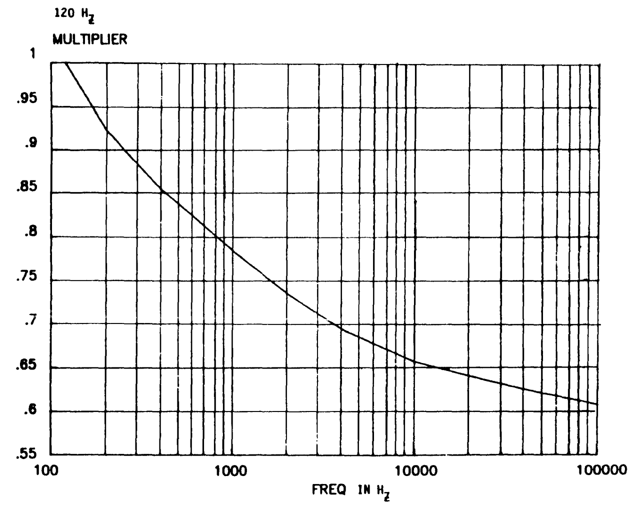


Fig. 3 HI FREQ. ESR MULTIPLIER 251-450 VOLT



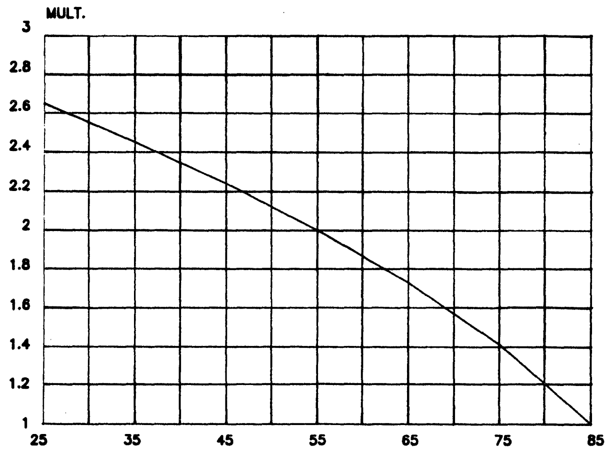
2.0 RIPPLE CURRENT.

All capacitors will withstand the RMS ripple current stated in the standard rating tables, specified at an ambient temperature of 85°C and a frequency of 120 Hz. Permissible ripple current at other temperatures, frequencies and with forced air can be calculated as indicated below. Where capacitors are operated at a temperature frequency and in forced air, all applicable multiplying factors should be used.

2.1 TYPICAL RIPPLE CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE.

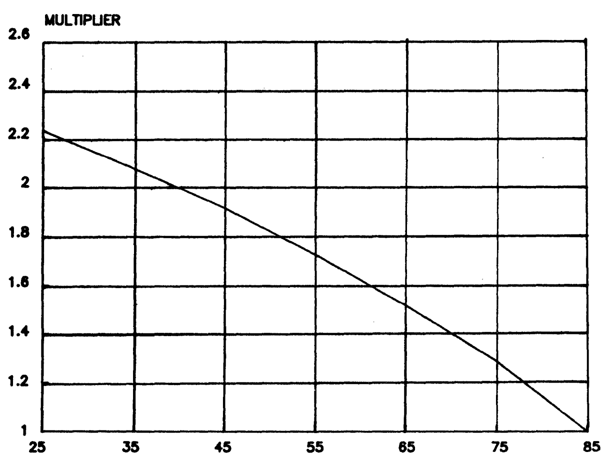
To determine the maximum allowable ripple current at ambient temperatures less than 85°C, find the ripple current multiplier from the appropriate curve (fig. 4, 5, or 6). The multiplier times the 85°C ripple current rating yields the maximum allowable ripple current at the subject temperature.

Fig. 4 RIPPLE MULTIPLIER 95 DEGREE CORE



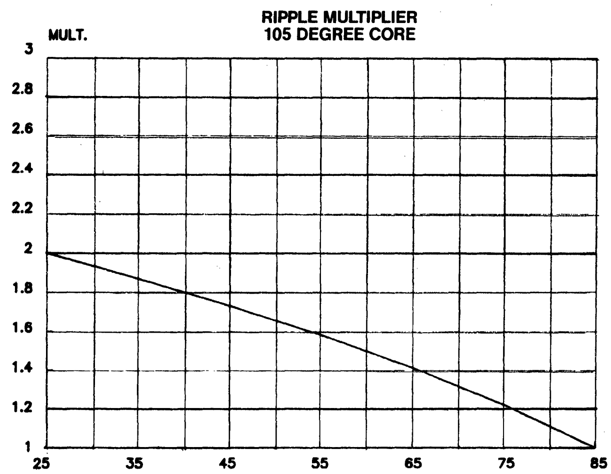
AMB. TEMP. (DEGREES C) 3186 SERIES 3487

Fig. 5 RIPPLE MULTILPLIER 100 DEGREE CORE



AMB. TEMP. (DEGREES C) 3191 SERIES

Fig. 6 RIPPLE MULTIPLIER 105 DEGREE CORE



AMB. TEMP (DEGREES C) 3188 & 3488 SERIES

2.2 TYPICAL RIPPLE CURRENT AS A FUNCTION OF FREQUENCY.

To determine the maximum allowable ripple current at frequencies above 120 Hz to 100 KHz, find the ripple current multiplier from the appropriate curve (fig. 7, 8 or 9). The multiplier times the 120 Hz ripple current rating yields the maximum allowable ripple current at the subject frequency.

Fig. 7 HI FREQ. RIPPLE CURRENT MULTIPLIER 0-75 VOLT

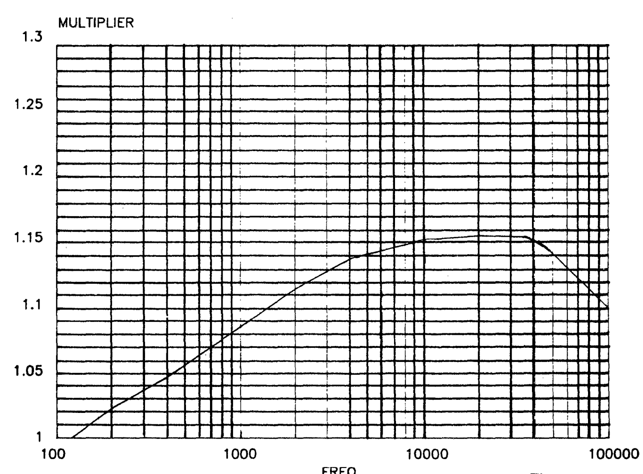


Fig. 4

Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

Fig. 8 HI FREQ. RIPPLE CURRENT MULTIPLIER 76-250 VOLT

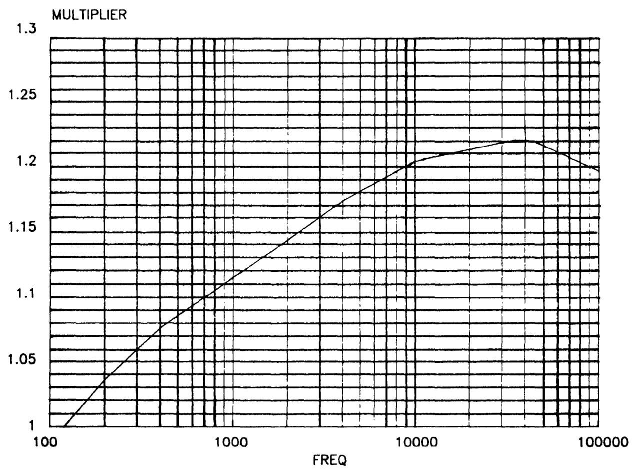
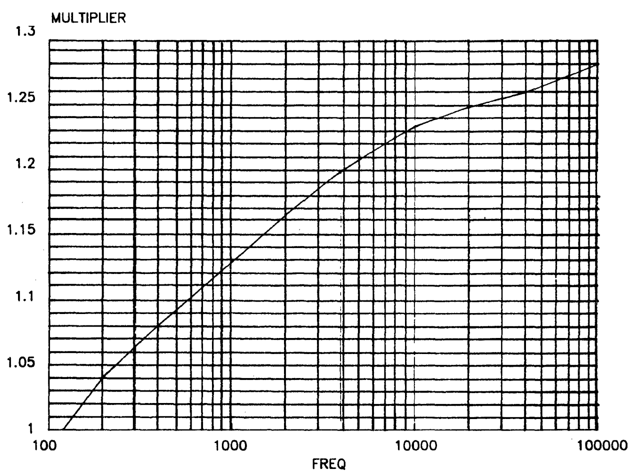


Fig. 9 HI FREQ. RIPPLE CURRENT MULTIPLIER 251-450 VOLT



2.3 TYPICAL RIPPLE CURRENT AS A FUNCTION OF FORCED AIR FLOW.

Thermal efficiency can be boosted by judicious use of forced air cooling in some applications. Occasionally a power-supply designer will calculate the proper capacitance value for the filter, then find that the ripple current requirements exceed the capability of the selected capacitor. The need for adding more capacitance in this situation can often be avoided if forced air is used to increase the ripple current capability of the capacitor. To determine the maximum allowable ripple current under a forced air application, find the ripple current multiplier from the appropriate curve (fig. 10).

The multiplier times the still air ripple current rating yields the maximum allowable ripple current at the subject air flow. The thermal conductivity with respect to the air velocity is illustrated in figure 11.

Fig. 10 RIPPLE CURRENT MULTIPLIER

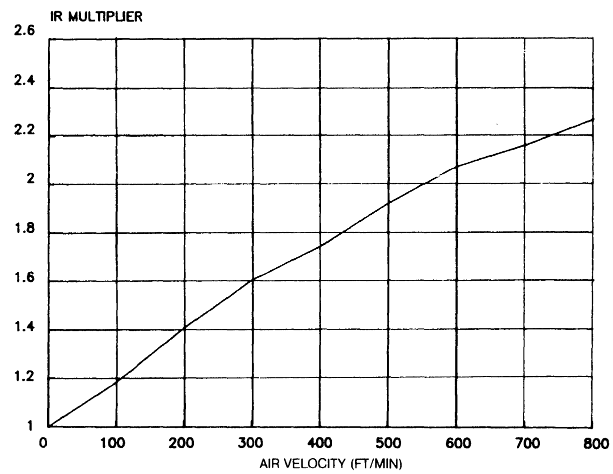
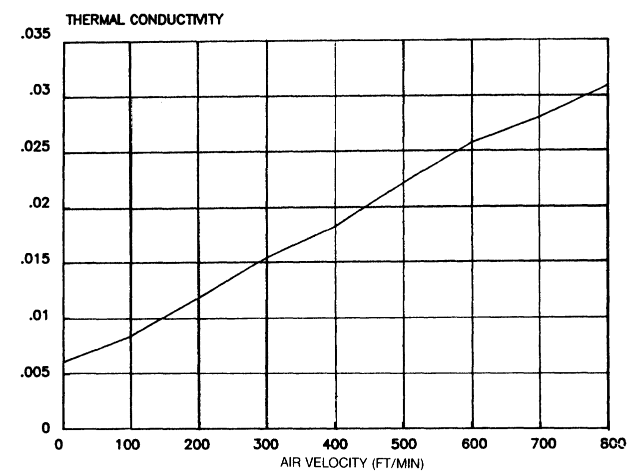


Fig. 11 THERMAL CONDUCTIVITY ($W/IN^2/DEG$ C)



3. TERMINAL HEAT RISE.

To limit terminal heat rise, the 85°C ripple current should not exceed the following RMS values:

Standard Terminal 30 amps
High-Current Terminal: 50 amps

When ripple currents greater than 10 amperes RMS are applied to these capacitors, the terminal screws should be torqued to aminimum of 20-inch-pounds (maximum, 25-inch-pounds) for standard terminals and 50-inch pounds (maximum, 60-inch-pounds) for high-current terminals to minimize I^2R losses at the terminals.

4. RIPPLE VOLTAGE AND VOLTAGE REVERSAL.

The sum of the DC voltage and peak ripple voltage must not exceed the rated voltage of the capacitor.

To avoid polarity reversal on the capacitor, the peak AC voltage applied must not exceed the applied DC voltage. All Series can withstand a maximum voltage reversal of 1.5 volts for short periods of time as indicated, without any significant change in electrical characteristics.

5. INSULATION AND GROUNDING.

These capacitors have an indeterminated resistance between the cathode terminal and the container. The container should be considered to be at the same potential as the cathode terminal with respect to ground. When a potential other than that of chassis ground is present on the cathode terminal, the container should be properly insulated.

5.1 INSULATING SLEEVE.

These capacitors may be supplied with PVC insulation for 85°C ambient operation.

The insulation shall be tested in accordance with EIA specification RS-395 paragraph 2.19.

The typical insulation breakdown voltages measured between the cathode terminal or case and a 1″ metallic band wrapped around the insulated container are as follows, at a relative humidity of 45%, ambient temperature of 25°C, and breakdown current of 1000μA:

PVC

Insulation Thickness	.004″	.006″	.008″	.012″
Breakdown Voltage (VAC)	1600	2000	2400	3200

6. SAFETY VENT.

SERIES 3487, 3488, 3407, 3408

A unique vent is designed into either the top or side of the aluminum can, so constructed that the end of the can will rupture and release dangerous internal pressure which could occur in the event of a circuit malfunction or polarity reversal.

Series 3186, 3188, 3191:

These capacitors are designed with safety device incorporated in the header. This device prevents case rupture or cover damage in event of excess pressure build-up due to improper operation.

Vent Test: A reverse DC voltage shall be applied to the capacitor to cause a reverse current flow of 10 amperes. The capacitor should be securely mounted to a surface by wrap-around clamp during this test. The vent should operate before an explosion or the expulsion of any capacitor material occurs. A capacitor which does not vent within 20 minutes is considered to have passed the vent test.

7. MOUNTING

SERIES 3186, 3188, 3919: Vertical mounting of the capacitor with the terminals up is recommended: however, horizontal mounting with the pressure relief vent up is acceptable. Vertical mounting with the terminals down and horizontal mounting with the pressure relief vent down are not recommended, since this could impair the operation of the safety vent.

Series 3487, 3488, 3407, 3408. These capacitors may be mounted in any plane.

8. CLEANING SOLVENT WARNING AND DISCLAIMER.

Industry standards such as EIA RS-395 and Military Specification MIL-C-39018 caution against the use of halogenated hydrocarbon solvents in cleaning boards containing aluminum electrolytic capacitors. The probability of failures in capacitors cleaned by halogenated hydrocarbon solvents is sufficient for Philips Components to disclaim any warrenties, specific or implied, to our product if our capacitors are subjected in any manner or extent to these solvents.

Examples of these solvents are Freon TMS®, Freon TMC®, carbon tetrachloride, chloroform, trichloroethylene, trichloroethane, methylene chloride and MEK. Recommended solvents are those free of halogens or halogen groups, such as ethyl alcohol, butyl alcohol, methyl alcohol, propyl alcohol, and water.

If halogenated hydrocarbon solvents must be used, the following alternatives exist:

a. The electrolytic capacitors should be inserted into the boards after the cleaning process has been completed.
b. On Special order, Philips Components can supply snap-in designs to meet solvents requirements.

SAFETY

With capacitors having a high watt-second capability it is important that suitable precautions be observed in the testing and application of these devices. Bleeder resistors and other discharge circuitry should be used to protect servicemen and users. When used in large banks, the mechanical structure must be designed so as to withstand the large currents that may occur in the event of a capacitor short circuit. The mechanical structure should also be constructed so that it will contain the capacitors if a capacitor explosion should occur.

Misapplications, such as exceeding design limits or applying reverse voltage to polar units, may result in destruction or explosion of capacitors.

Precautions in case of vent operation. Operation of the vent structure involves expulsion of hot gases and/or liquids under high pressure. Contact with this material could cause personal injury or property damage and therefore should be avoided.

GENERAL

In the event that application requirements exceed the parameters of a particular Series, it is often possible to use a standard capacitor, providing certain "trade-offs" are acceptable. It is also possible that special designs and manufacturing techniques not normally included can be applied to meet a special situation. These include the following:

- Higher Vibration Limits
- Higher Ripple Current
- Lower ESR
- Non-Polar Construction
- Solder-Lug Terminals
- Metric Threaded Terminals
- Special Capacitance Tolerance
- Special Marking and Labeling
- Additional Case Sizes

More specific device parameters can be obtained on request, these include:

- ESR at any Frequency (to 100kHz)
- Ripple Current Rating at any Frequency (to 100kHz)
- Impedance and ESR vs. Frequency Plots
- Inductance

Design Engineering Notes—Series 3000

About This Section...

In these notes, we discuss and analyze the major design problems most frequently encountered in capacitor applications. The presentation assumes that the reader has: (1) read the immediately preceding sections entitled Modern Electrolytic Capacitor Technology and Technical Notes (pages 00); (2) acquired adequate experience in conventional circuit design; and (3) gained reasonable facility with the mathematics of linear-circuit computations. Where appropriate, an accesible bibliographic reference is given.

We have attempted to make this presentation mathematically rigorous and physically realistic. When a simplifying assumption has been made, it has been noted . . . and, if necessary, explained.

One final word: these are the design-engineering topics that we feel you are most likely to encounter; but there are many others that arise less frequently, yet are challenging, and can be critical to circuit performance and reliability. You are invited to consult us about any such engineering problem in the application or selection of aluminum electrolytic capacitors. Write or call:

Applications Engineering Department
Philips Components
6071 St. Andrews Rd.
Columbia, South Carolina 29212-3198

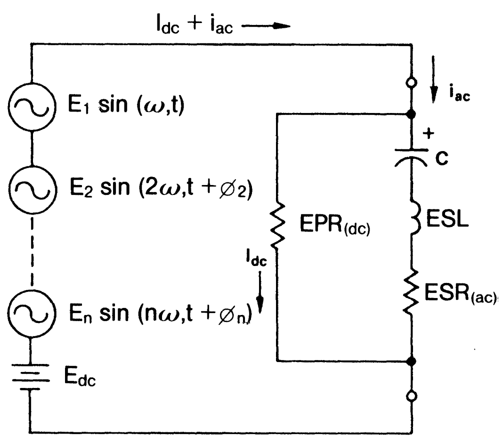


Fig. 1.
Equivalent circuit of an electrolytic capacitor and for non-sinusoidal (but periodic) AC ripple voltage with significant DC component.

*See any text dealing with spectral analysis. Publications like the ITT handbook (any edition) are also useful aids.

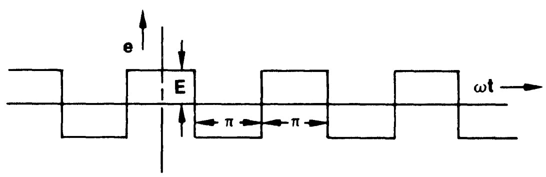
Ripple Voltage and Current; Total Dissipation. Figure 1 shows the "general cases" for both the applied voltage and the parameters of the equivalent circuit of the capacitor. Note the following:

1. The applied voltage comprises the series combination of a dc voltage and a periodic ac waveform of unvarying shape and amplitude. By Fourier analysis,* it can be shown that any continuous, periodic waveform can be expressed as the sum of a set of sinewave signals of various relative amplitudes and phases. The lowest-frequency signal has a frequency $f_1 = 1/\tau$, where τ is the period of the original waveform. The other sinewave signals in the set occur at integral multiples of that lowest frequency (i.e., at $2/\tau$, $3/\tau$, $4/\tau$ . . . n/τ), and are called the "second, third, fourth, . . . and nth harmonic components of the original waveform.
2. The amplitudes and phases of all harmonic components present can be computed from the Fourier integral and the geometry of the original ac ripple-voltage waveform. Although some waveforms have an infinite number of harmonic components, the amplitudes of the higher-order harmonics are negligibly small. In waveforms exhibiting "mirror symmetry" (between the geometries above and below E_{dc}), only the odd harmonics exist—i.e., the fundamental and the third, fifth, seventh, etc. The phase relationships are often restricted to 0° and 180° (plus or minus sinewave polarities). Figure 2 shows a number of common periodic ac ripple waveforms and their Fourier expansions.
3. In precise ripple-current computations, the rms values of the individual harmonic current components may be individually determined, then summed by a formula that involves taking the square root of the sum of the squares of all significant harmonic current amplitudes, as shown in example #2, below.
4. There is one simpler case than that just described. It is illustrated in example #1, in which the ripple voltage is assumed to be a pure sine wave, at 120Hz; hence, there are no harmonic components. The ac impedance of the capacitor at 120Hz is known, from catalog data supplied, and need not be computed. In this one special case, the rms ripple current is computed simply by dividing the rms value of the applied ripple voltage by the (120-Hz) impedance of the capacitor. The dissipation due to ripple current is, then, $(I\ ac\ rms)^2$ X ESR. To this must be added the dissipation due to leakage, which is Edc X Idc, where Idc is the rated maximum leakage current at the operating temperature.
5. In the generalized equivalent circuit of the capacitor shown in the right-hand side of figure 1, the leakage resistor is shown as EPR, the Equivalent Parallel Resistance. It is safely assumed to be constant and independent of both applied voltage and frequency, provided that only the applied Edc is at least 30% of the rated working voltage of the capacitor. It is temperature-dependent to some extent. The methods

of measuring Idc and ESR are such as to separate them effectively. ERS is, however, sensitive to frequency, operating temperature, and (to a much lesser extent) to the applied dc and ac voltages.

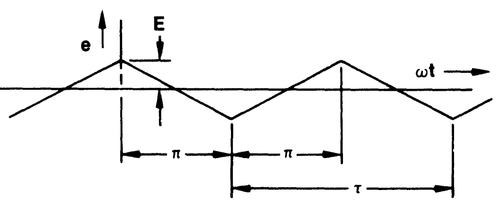
For All Waveforms

$\tau = \text{period} = \frac{1}{f} \quad 2\pi f = \omega \quad 2\pi ft = \omega t$



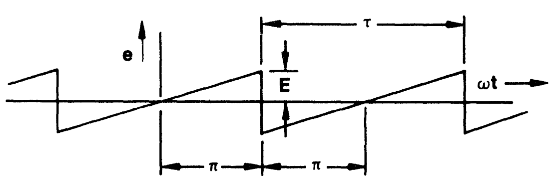
Square wave

$$e\,(t) = \frac{4}{\pi}E\left(\cos\,(\omega t - \frac{1}{3}\cos\,(3\omega t) + \frac{1}{5}\cos\,(5\omega t) - \frac{1}{7}\cos\,(7\omega t) + \ldots\right)$$



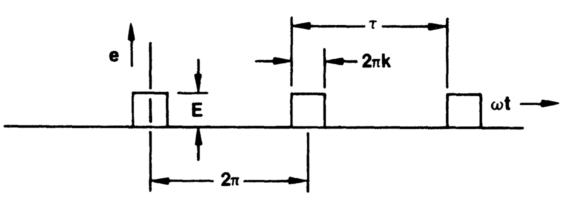
Triangular wave

$$e\,(t) = \frac{8}{\pi^2}\,E\left(\cos\,(\omega t + \frac{1}{9}\cos\,(3\omega t) + \frac{1}{25}\cos\,(5\omega t) + \ldots\right)$$



Sawtooth wave

$$e\,(t) = \frac{2}{\pi}E\left(\sin\,(\omega t - \frac{1}{2}\sin\,(2\omega t) + \frac{1}{3}\sin\,(3\omega t) - \frac{1}{4}\sin\,(4\omega t) + \ldots\right)$$

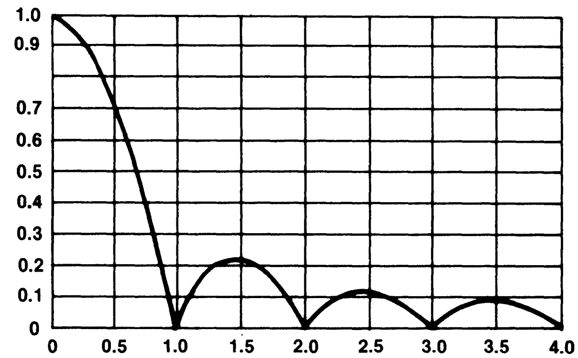


Short square pulse

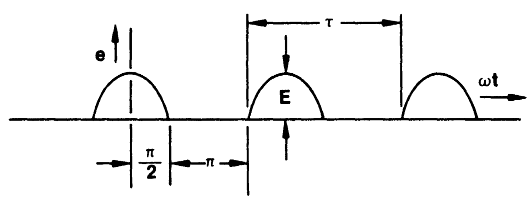
$$e\,(t) = E\left[k + \frac{2}{\pi}\left(\sin k\pi \cos\,(\omega t + \frac{1}{2}\sin 2k\pi \cos\,(2\omega t) + \frac{1}{3}\sin 3k\pi\cos\,(3\omega t) \ldots + \frac{1}{n}\sin nk\pi \cos\,(n\omega t) \ldots\right)\right]$$

Fig. 2.
Harmonic Composition of Some Common Periodic Waves.

The relative values of the coefficients of cos nx are plotted below as a function of nk for the case k<<1, i.e., for short pulse. Under these conditions the coefficients of cos nx are proportional to sin nkπ)/nkπ.

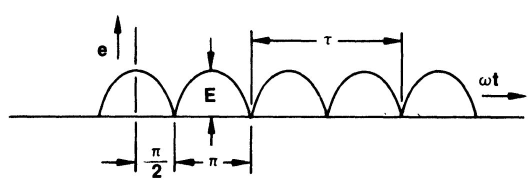


Relative amplitude of harmonics for k<<1.nk



Half-wave rectifier output

$$e\,(t) = \frac{1}{\pi}E\left(1 + \frac{\pi}{2}\cos\,(\omega t) + \frac{2}{3}\cos\,(\omega t) - \frac{2}{15}\cos\,(4\omega t) + \frac{2}{35}\cos\,(6\omega t) \ldots (-1)^{\frac{n}{2}+1}\,\frac{2}{n^2 - 1}\cos\,(n\omega t) \ldots\right)$$



Full-wave rectifier output

$$e\,(\omega t) = \frac{2}{\pi}E\left(1 + \frac{2}{3}\cos\,(2\omega t) - \frac{2}{15}\cos\,(4\omega t) + \frac{2}{35}\cos\,(6\omega t) \ldots (-1)^{\frac{n}{2}+1}\,\frac{2}{n^2 - 1}\cos\,(n\omega t) \ldots\right)$$

Returning to Figure 1, it should be clear that the left-hand side of the diagram represents any applied ripple voltage, having any dc component, and any amplitude and wavefore of variation, provided only that the variations are truly periodic. Thus, figures 1 and 2 provide the basis for a generalized technique for computing ripple current from applied voltage (of any waveform or period) and from the parameters of the capacitor.

The capacitor parameters are shown on right-hand side of figure 1. Remember that the methods used for measuring ESR and EPR keep them separate and independent. Therefore, EPR is assumed to dissipate power only due to the dc leakage current (Idc); and ESR is assumed to dissipate power only due to the rms ac ripple currents (appropriately summed as Iac), caused by the individual Fourier ac voltage components.

Example No. 1. This example considers the simplest practical case of the application of the foregoing theory. In it, the applied voltage is the sum of a dc voltage and a single sine wave. Such a ripple waveform is applied across the capacitor when a full-wave rectifier drives the capacitor through a multi-section low-pass, "choke-input." LC filter having a fairly sharp cutoff just above the fundamental ripple frequency. (Even a single large inductance between the full-wave rectifier and the capacitor closely approaches the example.) Given the applied voltage values and the capacitor parameters listed below, what dissipation occurs in the capacitor?

Edc $=200$V	$C=400\mu F$
Eac $=6\sin(\omega t)$	X_L at 120Hz$=0.008\Omega$
ω $=2\pi(120)=74_4$	ESR at 120Hz$=0.1\Omega$
	EPR at 250Vdc$=10^6\Omega$

The dc leakage current is simply the ratio of Edc to EPR, or

$$Idc = 200/10^6 = 200\mu A = 0.2mA$$

and this dissipates a power equal to the product of EDC and Idc, or

$$Pdc = 200 \times 0.2 \times 10^{-3} = 40mW = 0.04W$$

The ac computation is slightly more difficult, but equally straightforward, since only a single frequency is involved.

$$Zac = ESR + j\omega ESL - j\frac{1}{\omega C} \text{ (a vector sum)}$$

In this example, both ESR and $j\omega$ESL are negligibly small compared with $1/j\omega C$ at 120 Hz, so we may write:

$$Zac \cong 1/j\omega C$$

(Note that the normal data given for this capacitor includes its 120Hz impedence, which may be used in place of the $1/j\omega C$ computed for Zac) and we may ignore the j, since all it tells us is that the current Iac leads the applied ac voltage by 90°. Therefore,

$$Zac = 1/\omega C = 1/(400 \times 10^{-6} \times 754)$$

or $Zac = 3.32\Omega$

and we may the compute Iac

$$Iac = 6\sin(754t)/3.32 \times 1.81\sin(754t).$$

In other words, Iac is a sine wave of current having a peak value of 1.81 amperes. For a sine wave, the rms value is 0.707 times the peak value, so

$$Iac - 0.707 \times 1.81A = 1.28A \text{ rms}$$

and the power dissipated in ESR is

$$Pac \times (Iac\ rms)^2\ ESR = 0.16W$$

and the total power dissipated in the capacitor is

$$Pt = Pac + Pdc = 0.16W + 0.04W = 0.2W$$

Example No. 2. In this second example, we consider a 400μF capacitor with the same ESR and ESL, to which we apply a sawtooth ripple-voltage waveform, superimposed on a large Edc, as before. As we shall see later, this type of ripple waveform can occur when the rectangular-wave output of a switching regulator at, say, 95% duty cycle is fed to the capacitor through an inductor. Referring to figure 2, we find that the Fourier components of a sawtooth wave occur at both even and odd harmonics, diminishing in amplitude inversely as the order of the harmonic. If we assume a 3.14V peak-to-peak ripple amplitude superimposed on the 200V Edc, and $1/\tau = 400$Hz, what dissipation occurs in the capacitor?

Edc$=200$V	C $=400\mu F$
Eac$=3.14$V p-p sawtooth	
	ESL$=10.6\mu H$
	$X_L=0.008\Omega$ at 120Hz
$\tau=1/400$ seconds	ESR$=0.1\Omega$, assumed constant over the spectrum from 400Hz to 2,400 Hz*

The dc leakage current at 25°C and rated voltage is given by:

$$Idc = 200/10^6 = 0.2mA,$$

which causes a dissipation in EPR of:

$Pdc = 200 \times 0.2mA = 0.04W.$

*See typical DF-vs-frequency curve, figure 3. DF = (ESR × ΩC).

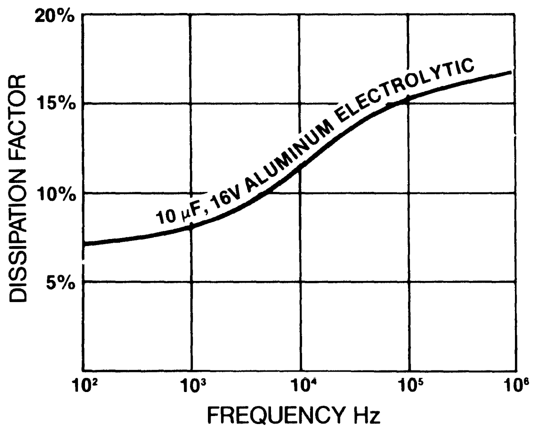


Fig. 3. DF vs. Frequency for Electrolytic Capacitors.

The ac computation is best handled by a chart format, as shown below.

f	ω(2πf)	E peak
400Hz	2,500	2v
800Hz	5,000	1V
1,200Hz	7,500	0.67V
1,600Hz	10,000	0.50V
2,000Hz	12,500	0.40V
2,400Hz	15,000	0.33V

$$e(t) = \frac{2}{\pi}(3.14)\ \sin(\omega t) - \frac{1}{2}\sin(2\omega t) + \frac{1}{3}(\sin 3\omega t) - \frac{1}{4}\sin(4\omega t) + \ldots$$

(The first six harmonics of sawtooth wave, from figure 2)

ω	1/ωC	ωL	ESR	1/ωC-ωL
2,500	1.0 Ω	0.0264Ω	0.1Ω	0.975Ω
5,000	0.5 Ω	0.0528Ω	0.1Ω	0.477Ω
7,500	0.33Ω	0.0792Ω	0.1Ω	0.251Ω
10,000	0.25Ω	0.1056Ω	0.1Ω	0.144Ω
12,500	0.20Ω	0.132Ω	0.1Ω	0.068Ω
15,000	0.10Ω	0.264Ω	0.1Ω	0.164Ω

ω	Zac	Epeak	Ipeak	Irms
2,500	1.04Ω	2.0V	1.9A	1.4A
5,000	0.55Ω	1.0V	1.8A	1.3A
7,500	0.27Ω	0.67V	2.5A	1.8A
10,000	0.17Ω	0.5V	2.9A	2.1A
12,500	0.12Ω	0.4V	3.3A	2.3A
15,000	0.19Ω	0.33V	1.7A	1.2A

ω	Irms	I^2rms	Pac (=ESRXI^2rms)
2,500	1.4A	2.0A²	0.2W
5,000	1.3A	1.7A²	0.17W
7,500	1.8A	3.3A²	0.33W
10,000	2.1A	4.4A²	0.44W
12,500	2.3A	5.3A²	0.53W
15,000	1.2A	1.4A²	0.14W

Pac = 1.81W (Fundamental through 6th harmonic)

The total power dissipated is given by:

$$Pt = Pdc + Pac = 0.04 + 1.81 = 1.85W$$

A number of useful facts may be deduced by analyzing and comparing the results of examples 1 and 2.

- At low-frequencies—i.e., well below resonance—only the capacitance and ESR are significant. Even the ripple-voltage waveform is not very important, if most or all of the high-amplitude harmonics fall below resonance. In both examples we have used a capacitor that is resonant at about 2.5kHz:

$$f_{res} = \frac{1}{2\pi\sqrt{LC}}$$

that is, the frequency at which

$$2\pi fL = \frac{1}{2\pi FC}$$

"L" in the above formula is the ESL of the capacitor. For L = 10.6μH and C = 400 μF, f_{res} = 2,445Hz.

- So great is the difference between signals falling well below resonance and those approaching resonance, that the 6V p-p ripple voltage of example 1 causes only about one-tenth the dissipation of the smaller signal (3.14V p-p) used in example 2 . . . because the smaller signal has harmonic components near the capacitor's resonant frequency; in fact, the fifth harmonic falls just below resonance, and the sixth is just above it.
- In both examples, note that we have used as a starting point the ripple voltage across the capacitor, not the ripple current flowing through it. If we had known the rms ripple current, then it would only have been necessary to square that current, and multiply the result by ESR:

$$Pac = (Irms)^2\ ESR\ watts.$$

- If a number of rms ripple current (e.g., at different frequencies, as in example 2) are to pass through the same ESR, the dissipation may be computed by the principle of superposition, using the sum-of-squares formula:

$$Pac = [(I_1)^2 + (I_2)^2 + (I_3)^2 + \ldots (In)^2]\ ESR\ watts$$ where I_1, I_2, I_3, etc. are each rms values.

Capacitor Calculations for Switching Regulator Output Circuits

For the specialist designer in motor controls and power supplies, this introductory treatment will, no doubt, convey very little new information. The technical literature of the past few years has piled up a mass of detailed analytical approaches, some of them involving complex mathematics.

For the engineer who wishes to make a good start on the design of the basic regulator (figure 4), and of many popular variations of this basic type, the following is well worth reading.

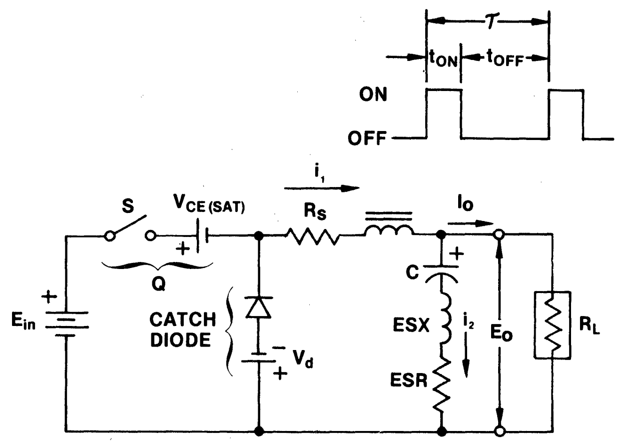


Fig 4. Equivalent circuit representative of many "constant-frequency," or duty-cycle-modulated switching regulators.

The circuit operates at a fixed frequency; that is, τ in figure 4 is a constant—say 100μsec for a 10 kHz regulator. The control of E_O is achieved by changing the duty cycle (α) of the control of the switching transistor.

$$\alpha = \left[1 - \frac{\tau on}{\tau}\right]$$

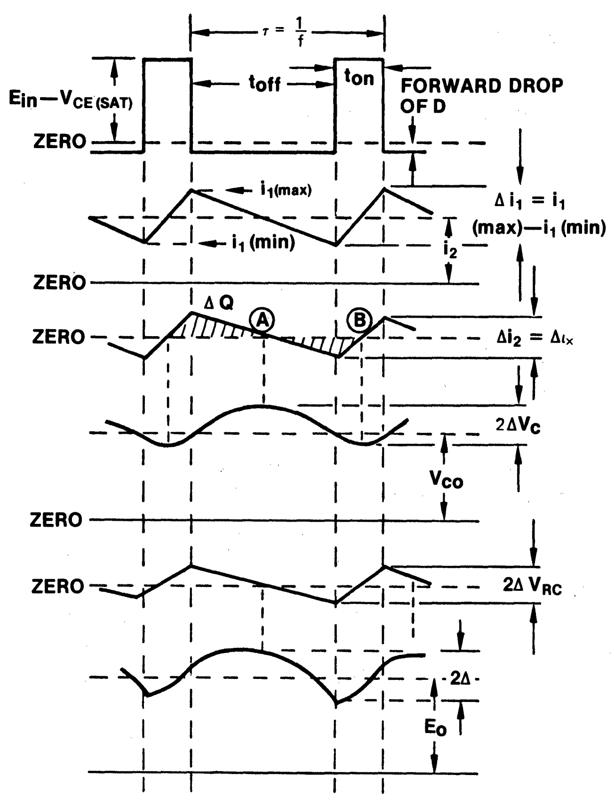


Figure 5 relates the various parameters around the circuit to critical currents and voltages that are established by the designer. Figure 5 presents a total of six sets of parametric curves, all synchronously related on a time "ladder," and the reader will find it possible, by moving from 5a to 5f, in various random sequences, to perform the three design tasks he must complete before the details of the electronics circuit can be attacked.

For example, figure 5f allows one to start with the required output voltage and the sum of the load and capacitor current (figure 5b) to read the product 2ΔVRC. From this computation, one can use figure 5d to determine the value of C.

One final note about figures 4 and 5. The results obtained from manipulations of figure 5 will not give completely valid results if the X_L shown in figure 4 is significant in magnitude to ESR. Furthermore, the results obtained in such a situation are "optimistic." Tending to yield smaller values of C and lower power dissipation. Using the new aluminum electrolytics with amide electrolytes, it is possible to obtain extremely large values of capacitance in which the X_L term is negligible compared to ESR.

It is obvious that we are not able to present the complete subject in this condensed summary. Two or three sample designs, however, treated as exercises, should serve to give the reader sufficient versatility with this rigorous and comprehensive view.

Fig. 5. Relationships among parameters of Figure 4, assuming X_L <<<ESR.

Fig. 5a. Voltage across D.

Fig. 5b. Current throught L. (i_2).

Fig. 5c. Current throught C. (i_2).

Fig. 5d. Voltage across capacitor c. (V_c).

Fig. 5e. Voltage across R_C. (V_{RC}).

Fig. 5f. Output voltage.

Fig. 18.
Measurement of
Ripple Current.

NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Axial leads, cylindrical aluminium case, insulated with a blue sleeve
- Mounting ring version (single ended) not insulated
- Case sizes 10 x 30 to 21 x 40 with safety vent
- Charge and discharge proof
- Taped versions up to 15 x 30 available for automatic insertion
- Miniaturized, high CU-product per unit volume.
- Low mounting height, vibration and shock resistant.

APPLICATIONS

- General purpose, industrial, automotive, audio-video
- Coupling, decoupling, smoothing, filtering, buffering and timing
- Portable and mobile equipment (small size, low mass)

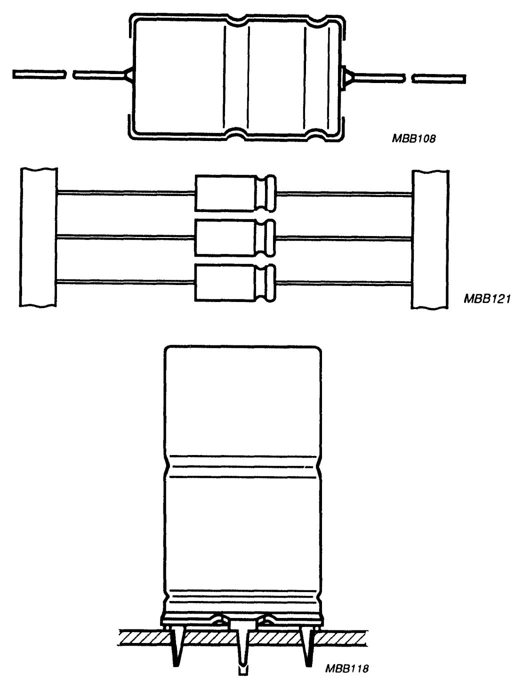


Fig.1 Component outlines.

QUICK REFERENCE DATA

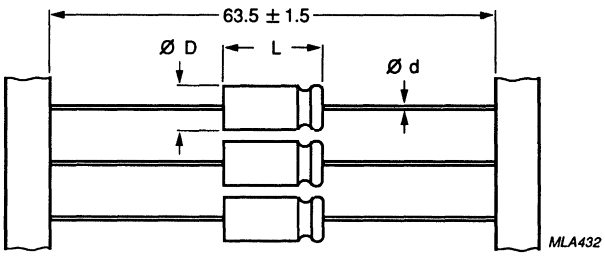
Case sizes ($\varnothing D_{nom}$ x L_{nom} in mm)	4.5 x 10 to 10 x 25	10 x 30 to 21 x 40
Rated capacitance range, C_R	0.22 to 15 000 µF	
Tolerance on C_R	±20%	
Rated voltage range, U_R	6.3 to 100 V	
Category temperature range	–40 to +85 °C	
Endurance test at 85 °C U_R = 6.3 to 25 V U_R = 40 to 100 V	 1000 hours 2000 hours	 5000 hours 5000 hours
Useful life at 85 °C	2500 hours	8000 hours
Useful life at 40 °C, 1.4 x I_R applied	70 000 hours	200 000 hours
Shelf life at 0 V, 85 °C	500 hours	500 hours
Basic specifications U_R = 6.3 to 25 V U_R = 40 to 100 V	IEC 384-4/CECC 30 300 GP grade LL grade	IEC 384-4/CECC 30 300 LL grade LL grade
Detail specifications	similar to DIN 41316 (with reduced dimensions)	
Climatic category IEC 68 DIN 40040	 40/085/56 GPF	

Table 1 Selection chart for C_RU_R and relevant nominal case sizes (**∅ D x L** in **mm**) ∗ = preferred values

C_R (µF)	U_R (V)						
	6.3	**10**	**16**	**25**	**40**	**63**	**100**
0.22						4.5 x 10∗	
0.47						4.5 x 10∗	
1						4.5 x 10∗	4.5 x 10∗
1.5						4.5 x 10	
2.2						4.5 x 10∗	4.5 x 10∗
3.3						4.5 x 10	
4.7						4.5 x 10∗	4.5 x 10∗
6.8						4.5 x 10	4.5 x 10
10						4.5 x 10∗	6 x 10∗
15						4.5 x 10	8 x 11 6.5 x 18
22					4.5 x 10∗	6 x 10∗	8 x 11∗ 6.5 x 18∗
33						6 x 10	6.5 x 18
47				4.5 x 10∗	6 x 10∗	8 x 11∗ 6.5 x 18∗	8 x 18∗ 6.5 x 25∗
68			4.5 x 10			8 x 11 6.5 x 18	10 x 18
100		4.5 x 10∗		6 x 10∗	8 x 11∗ 6.5 x 18∗	8 x 18∗ 6.5 x 25∗	10 x 25∗ 10 x 30∗
150			6 x 10	8 x 11 6.5 x 18	8 x 18 6.5 x 25	10 x 18	12.5 x 30
220		6 x 10∗	8 x 11∗	6.5 x 18∗	10 x 18∗	10 x 25∗ 10 x 30∗	12.5 x 30∗
330		8 x 11∗	6.5 x 18∗	8 x 18∗ 6.5 x 25∗	10 x 25∗	12.5 x 30∗	15 x 30∗
470	8 x 11∗	6.5 x 18∗	8 x 18∗ 6.5 x 25∗	10 x 18∗	10 x 25∗ 10 x 30∗	12.5 x 30∗	18 x 30∗
680		8 x 18 6.5 x 25	10 x 18	10 x 25∗ 10 x 30∗	12.5 x 30∗	15 x 30∗	18 x 40∗
1000	8 x 18∗ 6.5 x 25∗	10 x 18∗	10 x 25∗ 10 x 30∗	12.5 x 30∗	12.5 x 30∗	18 x 30∗	21 x 40∗
1500		10 x 25∗ 10 x 30∗	12.5 x 30∗	12.5 x 30∗	15 x 30∗	18 x 40∗	
2200	10 x 25∗	12.5 x 30∗	12.5 x 30∗	15 x 30∗	18 x 30∗	21 x 40∗	
3300		12.5 x 30∗	15 x 30∗	18 x 30∗	18 x 40∗		
4700		15 x 30∗	18 x 30∗	18 x 40∗	21 x 40∗		
6800		18 x 30∗	18 x 40∗	21 x 40∗			
10 000		18 x 40∗	21 x 40∗				
15 000		21 x 40∗					

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

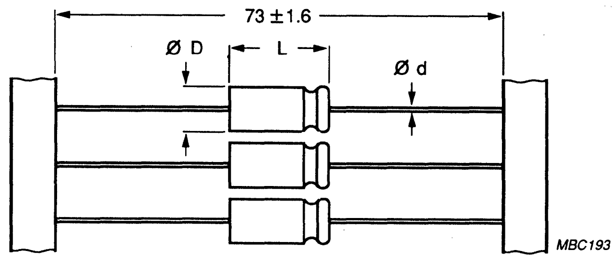
Dimensions in mm.
Tape dimensions are specified in chapter "PACKING",



Form BR: Taped on reel.

Form BA: Taped in box (ammopack).

Fig.2 Case sizes 4.5 x 10 to 8 x 11.



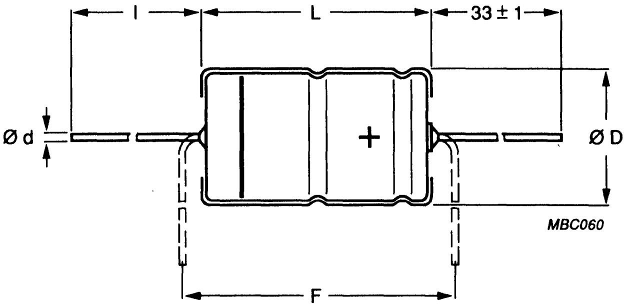
Form BR: Taped on reel, case sizes 6.5 x 18 to 15 x 30.

Form BA: Taped in box (ammopack), case sizes 6.5 x 18 to 10 x 25.

Fig.3 Case sizes 6.5 x 18 to 15 x 30.

Table 2 Axial, dimensions in mm; mass in g

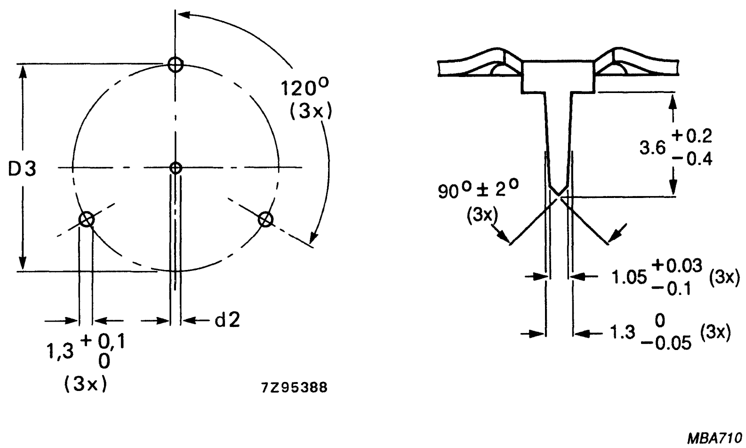
CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	AXIAL: Form AA, BA, and BR					APPROX. MASS	PACKING QUANTITIES		
		Ød	l	ØD_{max}	L_{max}	F_{min}		Form AA	Form BA	Form BR
4.5 x 10	2	0.6	–	5.0	10.5	15	0.50	–	1000	3000
6 x 10	3	0.6	–	6.3	10.5	15	0.70	–	1000	1000
8 x 11	5a	0.6	–	8.5	11.5	15	1.1	–	500	500
6.5 x 18	4	0.8	–	6.9	18.5	25	1.3	–	1000	1000
8 x 18	5	0.8	–	8.5	18.5	25	1.7	–	500	500
6.5 x 25	4L	0.8	–	6.9	25.0	30	1.9	–	1000	1000
10 x 18	6	0.8	–	10.5	18.5	25	2.5	–	500	500
10 x 25	7	0.8	–	10.5	25.0	30	3.3	–	500	500
10 x 30	00	0.8	55 ±1	10.5	30.5	35	4.8	200	–	500
12.5 x 30	01	0.8	55 ±1	13.0	30.5	35	7.4	200	–	400
15 x 30	02	0.8	55 ±1	15.5	30.5	35	11.7	200	–	250
18 x 30	03	0.8	55 ±1	18.5	30.5	35	12.9	200	–	–
18 x 40	04	0.8	34 ±1	18.5	41.5	45	19.4	100	–	–
21 x 40	05	0.8	34 ±1	21.5	41.5	45	24.7	100	–	–



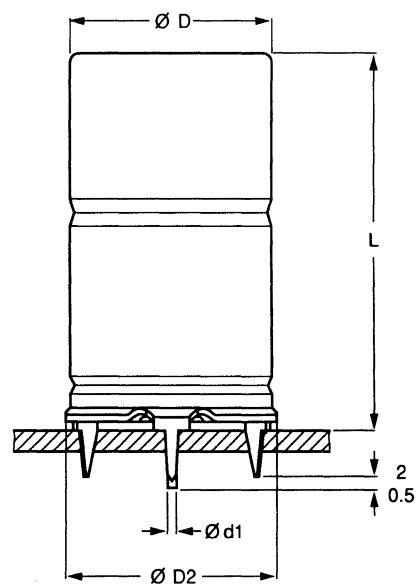
Form AA: Axial in box.

For case sizes 18 x 40 and 21 x 40, the stated L may be exceeded by 0.7 mm.

Fig.4 Case sizes 10 x 30 to 21 x 40.



Piercing diagram.



Form MR: case not insulated (insulation on request).

Especially for applications with severe shocks and vibrations.

Fig.5 Case sizes 15 x 30 to 21 x 40, single ended with mounting ring and pins.

Table 3 Single ended, dimensions in mm; mass in g

CASE SIZE $\varnothing D_{nom} \times L_{nom}$	CASE CODE	SINGLE ENDED WITH MOUNTING RING: Form MR					APPROX. MASS	PACKING QUANTITIES
		$\varnothing d_1$	$\varnothing d_2$	$\varnothing D2_{max}$	D3	L_{max}		
15 x 30	02	0.8	1.0 +0.1	17.5	16.5 ±0.2	33	11.7	200
18 x 30	03	0.8	1.0 +0.1	19.5	18.5 ±0.2	33	12.9	200
18 x 40	04	1.0	1.3 +0.1	19.5	18.5 ±0.2	45	19.4	100
21 x 40	05	1.0	1.3 +0.1	22.5	21.5 ±0.2	45	24.7	100

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 4 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R = rated capacitance at 100 Hz, tolerance ±20%
I_R = rated RMS ripple current at 100 Hz, 85 °C
I_{L1} = max. leakage current after 1 minute at U_R
I_{L5} = max. leakage current after 5 minutes at U_R
tan δ = max. dissipation factor at 100 Hz
ESR = equivalent series resistance at 100 Hz (calculated from tan δ max. and C_R)
Z = max. impedance at 10 kHz.

Table 4 Electrical data

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
6.3	470	8 x 11	260	22	10	0.25	0.85	0.64
	1000	8 x 18	440	42	17	0.25	0.4	0.5
	1000	6.5 x 25	420	42	17	0.30	0.48	0.5
	2200	10 x 25	710	87	32	0.29	0.21	0.16
10	100	4.5 x 10	100	10	6	0.20	3.2	2.0
	220	6 x 10	160	17	8.4	0.20	1.5	0.91
	330	8 x 11	230	24	11	0.20	1.0	0.61
	470	6.5 x 18	310	32	13	0.20	0.68	0.43
	680	8 x 18	400	45	18	0.20	0.47	0.29
	680	6.5 x 25	420	45	18	0.20	0.47	0.29
	1000	10 x 18	550	64	24	0.20	0.32	0.20
	1500	10 x 25	690	94	34	0.23	0.25	0.18
	1500	10 x 30	740	94	34	0.23	0.245	0.18
	2200	12.5 x 30	800	136	48	0.25	0.177	0.095
	3300	12.5 x 30	1000	202	70	0.27	0.128	0.095
	4700	15 x 30	1180	286	98	0.29	0.100	0.07
	6800	18 x 30	1480	412	140	0.34	0.079	0.065
	10 000	18 x 40	1860	604	204	0.40	0.064	0.04
	15 000	21 x 40	2250	904	304	0.50	0.054	0.035

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 021 . . . . .
1000 µF/16 V, ±20%
Case size 10 x 25; Form BR
Catalogue number: 2222 021 90517

Table 5

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
6.3	470	8 x 11	5a	–	021 23471	021 33471	–
	1000	8 x 18	5	–	021 23102	021 33102	–
	1000	6.5 x 25	4L	–	021 90592	021 90593	–
	2200	10 x 25	7	–	021 90588	021 90589	–
10	100	4.5 x 10	2	–	021 24101	021 34101	–
	220	6 x 10	3	–	021 24221	021 34221	–
	330	8 x 11	5a	–	021 24331	021 34331	–
	470	6.5 x 18	4	–	021 24471	021 34471	–
	680	8 x 18	5	–	021 24681	021 34681	–
	680	6.5 x 25	4L	–	021 90594	021 90595	–
	1000	10 x 18	6	–	021 24102	021 34102	–
	1500	10 x 25	7	–	021 90524	021 90525	–
	1500	10 x 30	00	021 14152	021 24152	–	–
	2200	12.5 x 30	01	021 14222	021 24222	–	–
	3300	12.5 x 30	01	021 14332	021 24332	–	–
	4700	15 x 30	02	021 14472	021 24472	–	021 44472
	6800	18 x 30	03	021 14682	–	–	021 44682
	10 000	18 x 40	04	021 14103	–	–	021 44103
	15 000	21 x 40	05	021 14153	–	–	021 44153

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
16	68	4.5 x 10	90	11	6.2	0.16	3.8	2.4
	150	6 x 10	140	18	8.8	0.16	1.7	1.1
	220	8 x 11	210	25	11	0.16	1.2	0.73
	330	6.5 x 18	290	36	15	0.16	0.77	0.48
	470	8 x 18	380	49	19	0.16	0.55	0.34
	470	6.5 x 25	400	49	19	0.16	0.55	0.34
	680	10 x 18	500	69	26	0.16	0.38	0.24
	1000	10 x 25	660	100	36	0.16	0.26	0.18
	1000	10 x 30	700	100	36	0.16	0.260	0.175
	1500	12.5 x 30	740	148	52	0.19	0.205	0.095
	2200	12.5 x 30	890	216	74	0.21	0.150	0.095
	3300	15 x 30	1130	321	110	0.23	0.111	0.07
	4700	18 x 30	1410	455	154	0.25	0.087	0.065
	6800	18 x 40	1780	656	222	0.30	0.070	0.04
	10 000	21 x 40	2170	964	324	0.36	0.058	0.035
25	47	4.5 x 10	80	11	6.4	0.14	4.8	2.6
	100	6 x 10	150	19	9	0.14	2.3	1.2
	150	8 x 11	190	27	12	0.14	1.5	0.80
	150	6.5 x 18	210	27	12	0.14	1.5	0.80
	220	6.5 x 18	250	37	15	0.14	1.0	0.55
	330	8 x 18	340	54	21	0.14	0.68	0.36
	330	6.5 x 25	350	54	21	0.14	0.68	0.36
	470	10 x 18	450	75	28	0.14	0.48	0.26
	680	10 x 25	560	106	38	0.14	0.33	0.18
	680	10 x 30	640	106	38	0.14	0.323	0.175
	1000	12.5 x 30	720	154	54	0.14	0.220	0.095
	1500	12.5 x 30	790	229	79	0.17	0.179	0.095
	2200	15 x 30	1030	334	114	0.19	0.132	0.07
	3300	18 x 30	1310	499	169	0.21	0.099	0.065
	4700	18 x 40	1680	709	239	0.23	0.079	0.04
	6800	21 x 40	2070	1024	344	0.28	0.064	0.035

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U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
16	68	4.5 x 10	2	–	021 25689	021 35689	–
	150	6 x 10	3	–	021 25151	021 35151	–
	220	8 x 11	5a	–	021 25221	021 35221	–
	330	6.5 x 18	4	–	021 25331	021 35331	–
	470	8 x 18	5	–	021 25471	021 35471	–
	470	6.5 x 25	4L	–	021 90596	021 90597	–
	680	10 x 18	6	–	021 25681	021 35681	–
	1000	10 x 25	7	–	021 90517	021 90518	–
	1000	10 x 30	00	021 15102	021 25102	–	–
	1500	12.5 x 30	01	021 15152	021 25152	–	–
	2200	12.5 x 30	01	021 15222	021 25222	–	–
	3300	15 x 30	02	021 15332	021 25332	–	021 45332
	4700	18 x 30	03	021 15472	–	–	021 45472
	6800	18 x 40	04	021 15682	–	–	021 45682
	10 000	21 x 40	05	021 15103	–	–	021 45103
25	47	4.5 x 10	2	–	021 26479	021 36479	–
	100	6 x 10	3	–	021 26101	021 36101	–
	150	8 x 11	5a	–	021 90534	021 90535	–
	150	6.5 x 18	4	–	021 26151	021 36151	–
	220	6.5 x 18	4	–	021 26221	021 36221	–
	330	8 x 18	5	–	021 26331	021 36331	–
	330	6.5 x 25	4L	–	021 90598	021 90599	–
	470	10 x 18	6	–	021 26471	021 36471	–
	680	10 x 25	7	–	021 90527	021 90528	–
	680	10 x 30	00	021 16681	021 26681	–	–
	1000	12.5 x 30	01	021 16102	021 26102	–	–
	1500	12.5 x 30	01	021 16152	021 26152	–	–
	2200	15 x 30	02	021 16222	021 26222	–	021 46222
	3300	18 x 30	03	021 16332	–	–	021 46332
	4700	18 x 40	04	021 16472	–	–	021 46472
	6800	21 x 40	05	021 16682	–	–	021 46682

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
40	22	4.5 x 10	60	9	5.8	0.11	8.0	3.2
	47	6 x 10	110	15	7.8	0.11	3.8	1.5
	100	8 x 11	170	28	12	0.11	1.8	0.70
	100	6.5 x 18	190	28	12	0.11	1.8	0.70
	150	8 x 18	250	40	16	0.11	1.1	0.47
	150	6.5 x 25	260	40	16	0.11	1.1	0.47
	220	10 x 18	330	57	22	0.11	0.8	0.32
	330	10 x 25	430	83	30	0.11	0.53	0.21
	470	10 x 25	520	117	42	0.11	0.37	0.18
	470	10 x 30	570	117	42	0.12	0.404	0.175
	680	12.5 x 30	620	167	58	0.12	0.297	0.095
	1000	12.5 x 30	770	244	84	0.12	0.190	0.095
	1500	15 x 30	930	364	124	0.15	0.159	0.07
	2200	18 x 30	1200	532	180	0.17	0.118	0.065
	3300	18 x 40	1550	796	268	0.19	0.090	0.04
	4700	21 x 40	1880	1132	380	0.21	0.072	0.035

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
40	22	4.5 x 10	2	–	021 27229	021 37229	–
	47	6 x 10	3	–	021 27479	021 37479	–
	100	8 x 11	5a	–	021 90537	021 90538	–
	100	6.5 x 18	4	–	021 27101	021 37101	–
	150	8 x 18	5	–	021 27151	021 37151	–
	150	6.5 x 25	4L	–	021 90601	021 90602	–
	220	10 x 18	6	–	021 27221	021 37221	–
	330	10 x 25	7	–	021 27331	021 37331	–
	470	10 x 25	7	–	021 90514	021 90515	–
	470	10 x 30	00	021 17471	021 27471	–	–
	680	12.5 x 30	01	021 17681	021 27681	–	–
	1000	12.5 x 30	01	021 17102	021 27102	–	–
	1500	15 x 30	02	021 17152	021 27152	–	021 47152
	2200	18 x 30	03	021 17222	–	–	021 47222
	3300	18 x 40	04	021 17332	–	–	021 47332
	4700	21 x 40	05	021 17472	–	–	021 47472

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
63	0.22	4.5 x 10	5	4.1	4	0.09	650	250
	0.47	4.5 x 10	8	4.2	4.1	0.09	310	120
	1	4.5 x 10	12	4.4	4.1	0.09	150	55
	1.5	4.5 x 10	12	4.6	4.2	0.09	100	37
	2.2	4.5 x 10	21	4.8	4.3	0.09	65	25
	3.3	4.5 x 10	25	5.2	4.4	0.09	44	17
	4.7	4.5 x 10	31	5.8	4.6	0.09	31	12
	6.8	4.5 x 10	31	6.6	4.9	0.09	21	8.1
	10	4.5 x 10	50	7.8	5.3	0.08	13	5.5
	15	4.5 x 10	55	9.5	5.9	0.08	8.5	3.7
	22	6 x 10	90	12	6.8	0.08	5.8	2.5
	33	6 x 10	100	16	8.2	0.08	3.9	1.7
	47	8 x 11	140	22	10	0.08	2.7	1.2
	47	6.5 x 18	150	22	10	0.08	2.7	1.2
	68	8 x 11	160	30	13	0.08	1.9	0.81
	68	6.5 x 18	170	30	13	0.08	1.9	0.81
	100	8 x 18	250	42	17	0.08	1.3	0.55
	100	6.5 x 25	260	42	17	0.08	1.3	0.55
	150	10 x 18	320	61	23	0.08	0.85	0.37
	220	10 x 25	430	88	32	0.08	0.60	0.25
	220	10 x 30	480	88	32	0.08	0.614	0.20
	330	12.5 x 30	530	129	46	0.08	0.409	0.14
	470	12.5 x 30	630	182	63	0.08	0.287	0.10
	680	15 x 30	830	261	90	0.08	0.199	0.080
	1000	18 x 30	1120	382	130	0.08	0.135	0.065
	1500	18 x 40	1350	571	193	0.11	0.122	0.04
	2200	21 x 40	1780	836	281	0.13	0.099	0.035

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
63	0.22	4.5 x 10	2	–	021 28227	021 38227	–
	0.47	4.5 x 10	2	–	021 28477	021 38477	–
	1	4.5 x 10	2	–	021 28108	021 38108	–
	1.5	4.5 x 10	2	–	021 28158	021 38158	–
	2.2	4.5 x 10	2	–	021 28228	021 38228	–
	3.3	4.5 x 10	2	–	021 28338	021 38338	–
	4.7	4.5 x 10	2	–	021 28478	021 38478	–
	6.8	4.5 x 10	2	–	021 28688	021 38688	–
	10	4.5 x 10	2	–	021 28109	021 38109	–
	15	4.5 x 10	2	–	021 28159	021 38159	–
	22	6 x 10	3	–	021 28229	021 38229	–
	33	6 x 10	3	–	021 28339	021 38339	–
	47	8 x 11	5a	–	021 90541	021 90542	–
	47	6.5 x 18	4	–	021 28479	021 38479	–
	68	8 x 11	5a	–	021 90544	021 90545	–
	68	6.5 x 18	4	–	021 28689	021 38689	–
	100	8 x 18	5	–	021 28101	021 38101	–
	100	6.5 x 25	4L	–	021 90603	021 90604	–
	150	10 x 18	6	–	021 28151	021 38151	–
	220	10 x 25	7	–	021 90511	021 90512	–
	220	10 x 30	00	021 18221	021 28221	–	–
	330	12.5 x 30	01	021 18331	021 28331	–	–
	470	12.5 x 30	01	021 18471	021 28471	–	–
	680	15 x 30	02	021 18681	021 28681	–	021 48681
	1000	18 x 30	03	021 18102	–	–	021 48102
	1500	18 x 40	04	021 18152	–	–	021 48152
	2200	21 x 40	05	021 18222	–	–	021 48222

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
100	1	4.5 x 10	14	4.6	4.6	0.08	130	90
	2.2	4.5 x 10	20	5.3	5.3	0.08	58	41
	4.7	4.5 x 10	30	7	7	0.08	27	19
	6.8	4.5 x 10	35	8	8	0.08	19	13
	10	6 x 10	65	10	10	0.08	13	9
	15	8 x 11	77	13	13	0.08	8.5	6
	15	6.5 x 18	85	13	13	0.08	8.5	6
	22	8 x 11	95	17	17	0.08	5.8	4.1
	22	6.5 x 18	100	17	17	0.08	5.8	4.1
	33	6.5 x 18	120	24	24	0.08	3.9	2.7
	47	8 x 18	160	32	32	0.08	2.7	1.9
	47	6.5 x 25	170	32	32	0.08	2.7	1.9
	68	10 x 18	220	45	45	0.08	1.9	1.3
	100	10 x 25	300	64	64	0.08	1.3	0.9
	100	10 x 30	360	64	64	0.07	1.150	1.0
	150	12.5 x 30	420	94	94	0.07	0.645	0.61
	220	12.5 x 30	460	136	136	0.08	0.610	0.56
	330	15 x 30	580	202	202	0.09	0.420	0.40
	470	18 x 30	740	286	286	0.09	0.310	0.29
	680	18 x 40	1050	412	412	0.09	0.195	0.18
	1000	21 x 40	1260	604	604	0.10	0.160	0.15

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U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
100	1	4.5 x 10	2	–	021 29108	021 39108	–
	2.2	4.5 x 10	2	–	021 29228	021 39228	–
	4.7	4.5 x 10	2	–	021 29478	021 39478	–
	6.8	4.5 x 10	2	–	021 29688	021 39688	–
	10	6 x 10	3	–	021 29109	021 39109	–
	15	8 x 11	5a	–	021 90547	021 90548	–
	15	6.5 x 18	4	–	021 29159	021 39159	–
	22	8 x 11	5a	–	021 90551	021 90552	–
	22	6.5 x 18	4	–	021 29229	021 39229	–
	33	6.5 x 18	4	–	021 29339	021 39339	–
	47	8 x 18	5	–	021 29479	021 39479	–
	47	6.5 x 25	4L	–	021 90605	021 90606	–
	68	10 x 18	6	–	021 29689	021 39689	–
	100	10 x 25	7	–	021 90531	021 90532	–
	100	10 x 30	00	021 19101	021 29101	–	–
	150	12.5 x 30	01	021 19151	021 29151	–	–
	220	12.5 x 30	01	021 19221	021 29221	–	–
	330	15 x 30	02	021 19331	021 29331	–	021 49331
	470	18 x 30	03	021 19471	–	–	021 49471
	680	18 x 40	04	021 19681	–	–	021 49681
	1000	21 x 40	05	021 19102	–	–	021 49102

MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance (in µF)
- Tolerance on nominal capacitance (in accordance with IEC 62)
- Rated voltage (in V)
- Group number (021)
- Name of manufacturer (PHILIPS)
- Date code in accordance with IEC 62
- Code for factory of origin
- Band to identify the negative terminal
- "+" - signs to identify the positive terminal (not for case sizes L <18 mm).

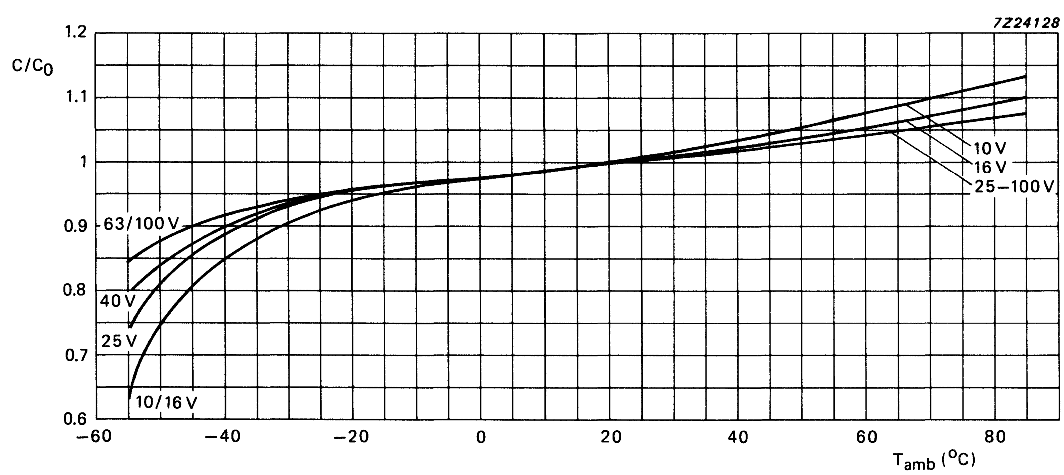
Voltage

Surge voltage for short periods	$U_s \leq 1.15 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

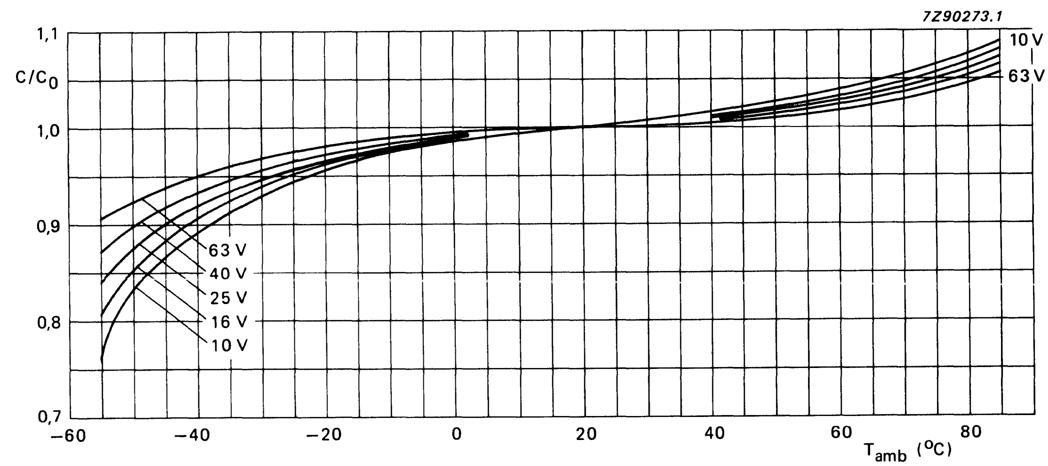
After 1 minute at U_R	$I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$
After 5 minutes at:	
U_R (6.3 to 63 V)	$I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$
U_R (100 V)	$I_{L5} \leq 0.006\ C_R \times U_R + 4\ \mu A$

Capacitance (C)



C_0 = capacitance at 20 °C, 100 Hz.
Case sizes 4.5 x 10 to 10 x 25.

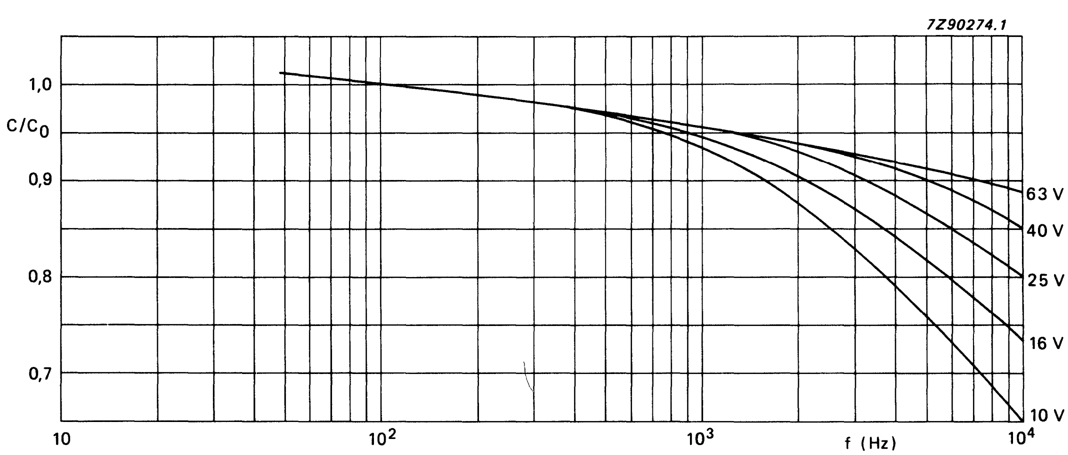
Fig.6 Multiplier of capacitance (C/C_0) as a function of ambient temperature.



C_0 = capacitance at 20 °C, 100 Hz.

Case sizes 10 x 30 to 21 x 40.

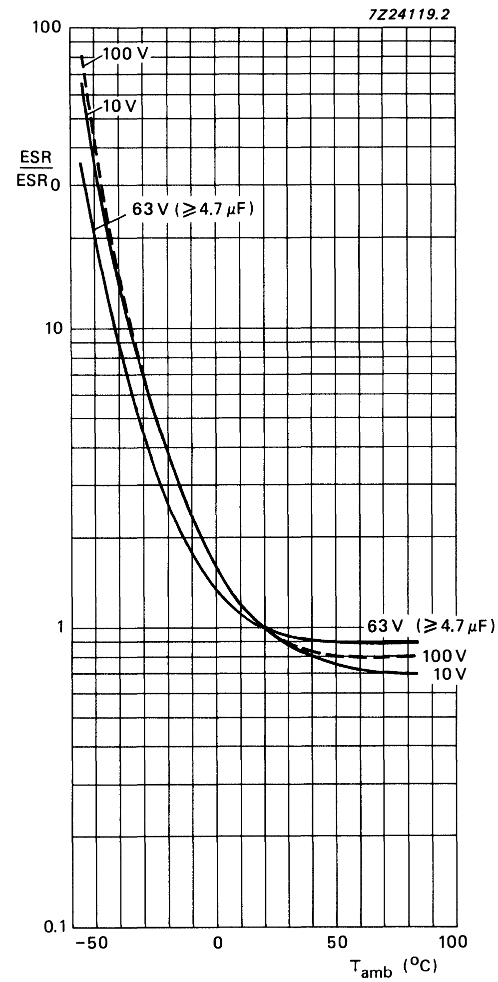
Fig.7 Multiplier of capacitance (C/C_0) as a function of ambient temperature.



C_0 = capacitance at 20 °C; 100 Hz.

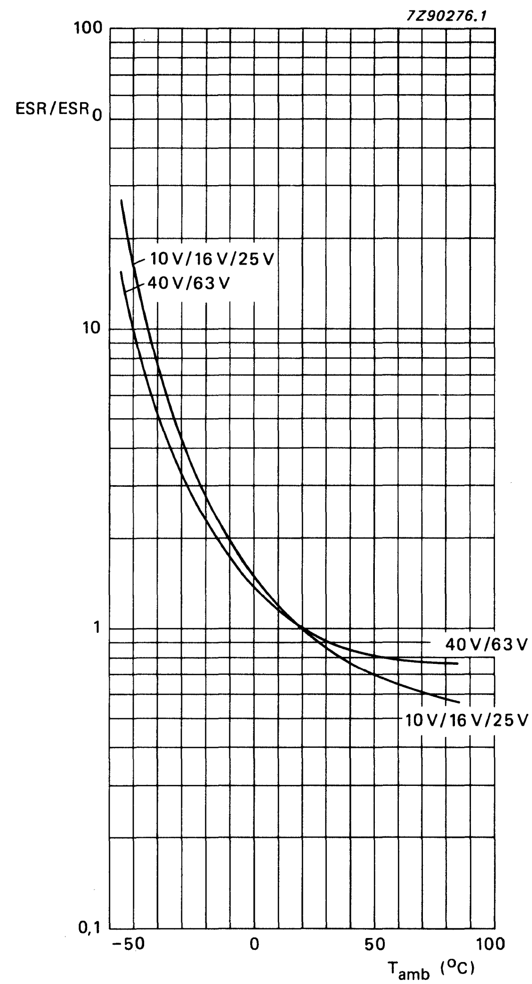
Fig.8 Multiplier of capacitance (C/C_0) as a function of frequency.

Equivalent series resistance (ESR)



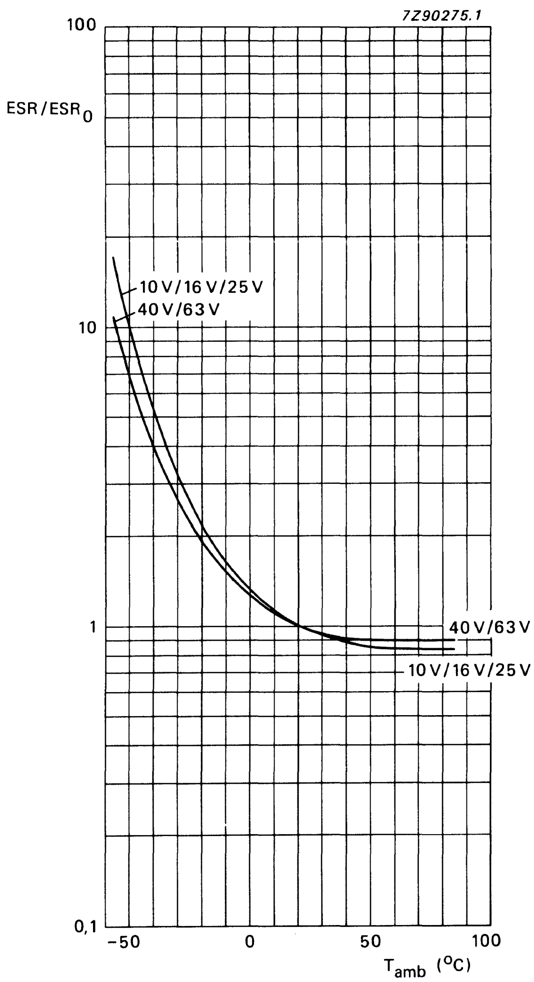
ESR_0 = typical ESR at 20 °C, 100 Hz.
Case sizes 4.5 x 10 to 10 x 25.

Fig.9 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature.



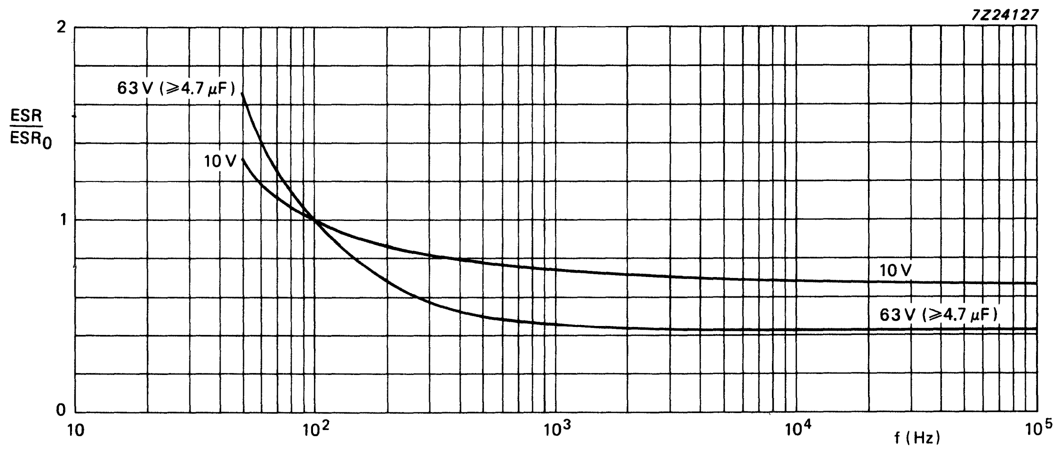
ESR_0 = typical ESR at 20 °C, 100 Hz.
Case sizes 10 x 30, 12.5 x 30 and 15 x 30.

Fig.10 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature.



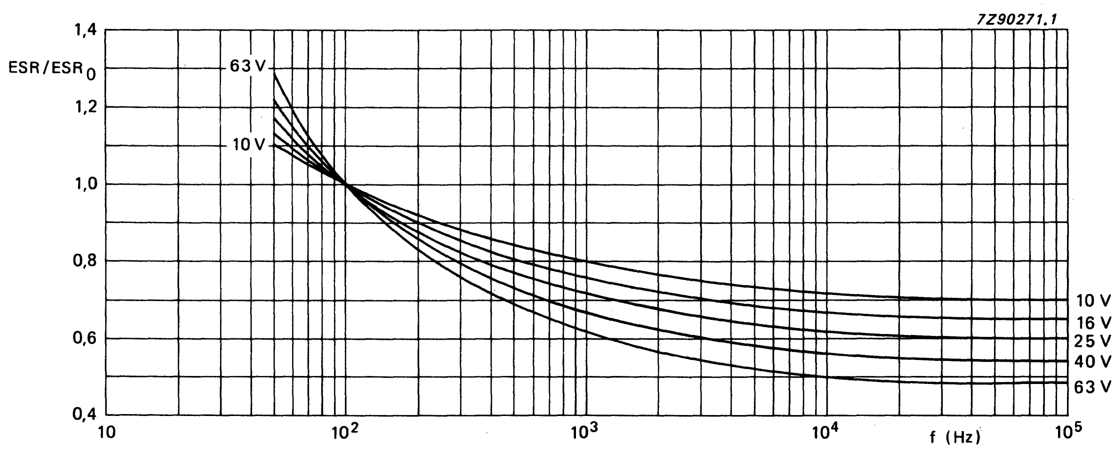
ESR_0 = typical ESR at 20 °C, 100 Hz.
Case sizes 18 x 30, 18 x 40 and 21 x 40.

Fig.11 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature.



ESR_0 = typical ESR at 20 °C, 100 Hz.
Case sizes 4.5 x 10 to 10 x 25.

Fig. 12 Multiplier of ESR (ESR/ESR_0) as a function of frequency.



ESR_0 = typical ESR at 20 °C, 100 Hz.
Case sizes 10 x 30 to 21 x 40.

Fig. 13 Multiplier of ESR (ESR/ESR_0) as a function of frequency.

Equivalent series inductance (ESL)

Table 6 Equivalent series inductance, typical values

CASE SIZE (∅D x L in mm)	AXIAL (nH)	MOUNTING RING (nH)
4.5 x 10	10	–
6 x 10	22	–
8 x 11	85	–
6.5 x 18	25	–
8 x 18	40	–
6.5 x 25	40	–
10 x 18	61	–
10 x 25	38	–
10 x 30	38	–
12.5 x 30	46	–
15 x 30	48	39
18 x 30	50	39
18 x 40	54	39
21 x 40	59	39

Impedance (Z)

Table 7 Impedance x capacitance values (case sizes 4.5 x 10 to 10 x 25 mm)

T_{amb}	$z = Z \times C_R$ (Ω μF) at 10 kHz						
	6.3 V	10 V	16 V	25 V	40 V	63 V	100 V
+20 °C	≤ 300	≤ 200	≤ 160	≤ 120	≤ 70	≤ 55	≤ 90
−25 °C	≤2000	≤1200	≤ 750	≤ 560	≤ 300	≤ 180	≤ 600
−40 °C	≤5500	≤3200	≤2000	≤1500	≤ 900	≤ 500	≤1600

Curve 1 : 1μF-63 V; 4.5 x 10
Curve 2 : 2.2μF- 63 V; 4.5 x 10
Curve 3 : 4.7μF-63 V; 4.5 x 10
Curve 4 : 10μF-63 V; 4.5 x 10
Curve 5 : 22μF-63 V; 6 x 10
Curve 6 : 47μF-40 V; 6 x 10
Curve 7 : 100μF-25 V; 6 x 10
Curve 8 : 220μF-25 V; 6.5 x 18
Curve 9 : 470μF-10 V; 6.5 x 18
Curve 10 : 1000μF-6.3 V; 6.5 x 25.

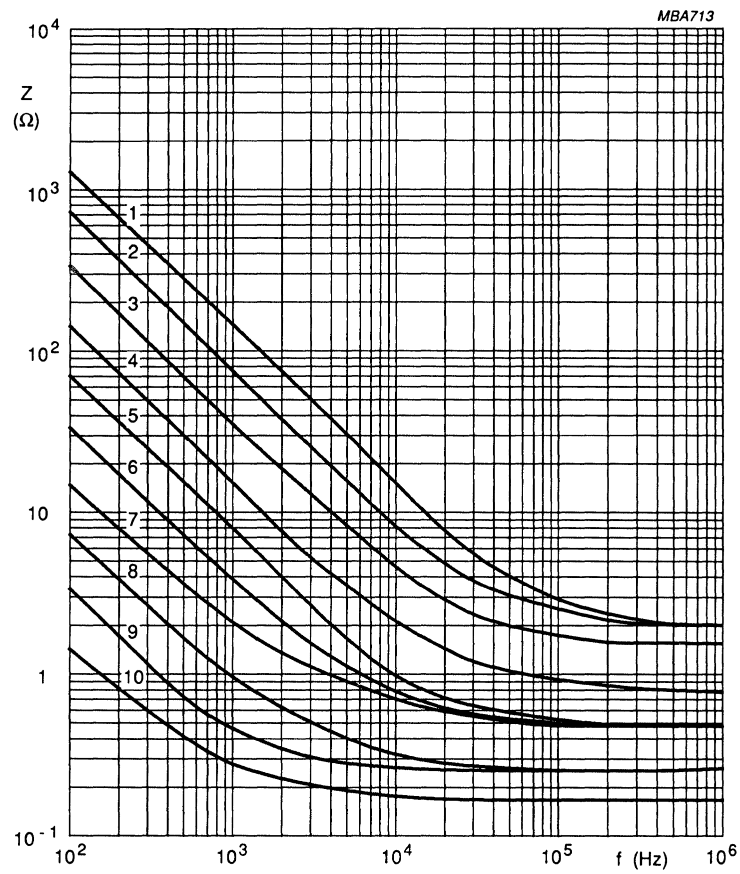


Fig.14 Typical impedance as a function of frequency; case sizes 4.5 x 10 to 6.5 x 25.

Curve 1 : 47µF-63 V; 8 x 11
Curve 2 : 100µF-63 V; 8 x 18
Curve 3 : 220µF-40 V; 10 x 18
Curve 4 : 470µF-25 V; 10 x 18
Curve 5 : 1000µF-10 V; 10 x 18
Curve 6 : 1000µF-16 V; 10 x 25
Curve 7 : 2200µF-6.3 V; 10 x 25.

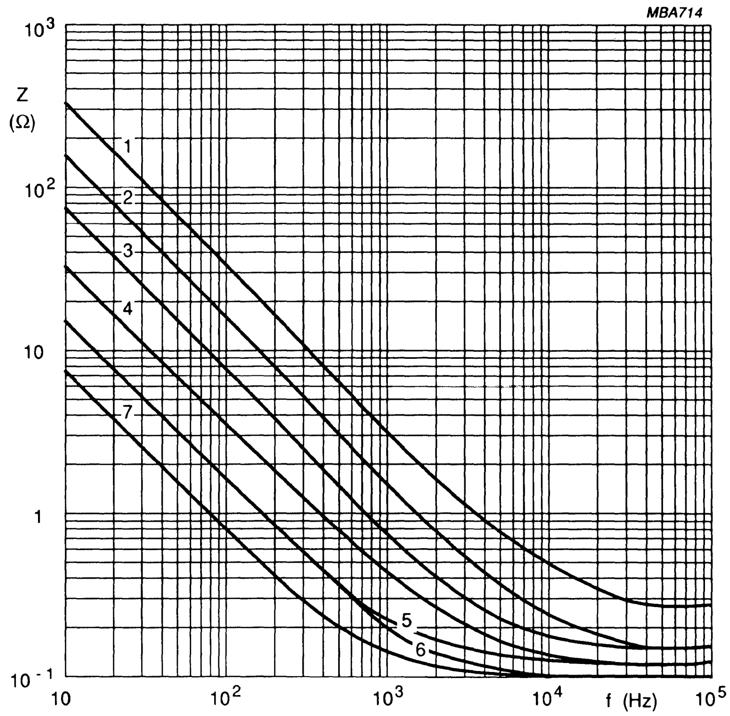


Fig.15 Typical impedance as a function of frequency; case sizes 8 x 11 to 10 x 25.

Curve 1 : 330µF-63 V
Curve 2 : 470 µF-63 V
Curve 3 : 680 µF-40 V
Curve 4 : 1000 µF-25 V and 40 V
Curve 5 : 1500 µF-16 V and 25 V
Curve 6 : 2200 µF-10 V and 16 V
Curve 7 : 3300 µF-10 V.

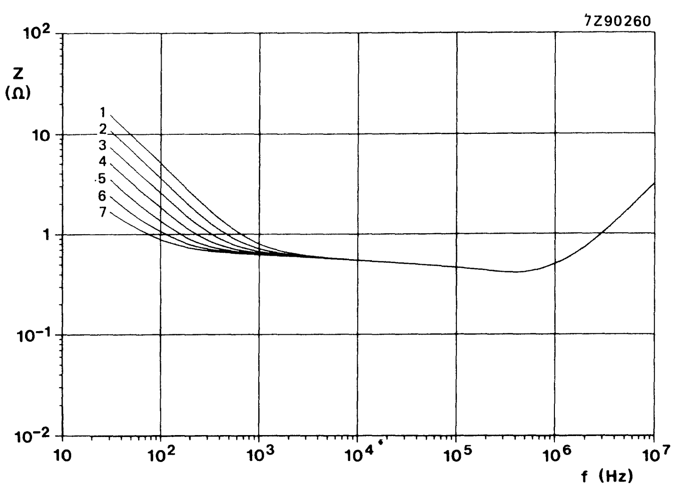


Fig.16 Typical impedance as a function of frequency at T_{amb} = –40 °C, case size 12.5 x 30.

Curve 1 : 330µF-63 V
Curve 2 : 470 µF-63 V
Curve 3 : 680 µF-40 V
Curve 4 : 1000 µF-25 V and 40 V
Curve 5 : 1500 µF-16 V and 25 V
Curve 6 : 2200 µF-10 V and 16 V
Curve 7 : 3300 µF-10 V.

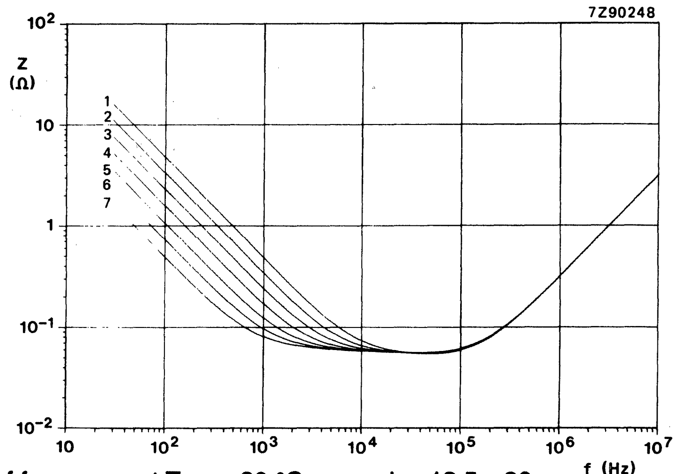


Fig.17 Typical impedance as a function of frequency at T_{amb} = 20 °C, case size 12.5 x 30.

Curve 1 : 1000 µF-63 V
Curve 2 : 2200 µF-40 V
Curve 3 : 3300 µF-25 V
Curve 4 : 4700 µF-16 V
Curve 5 : 6800 µF-10 V.

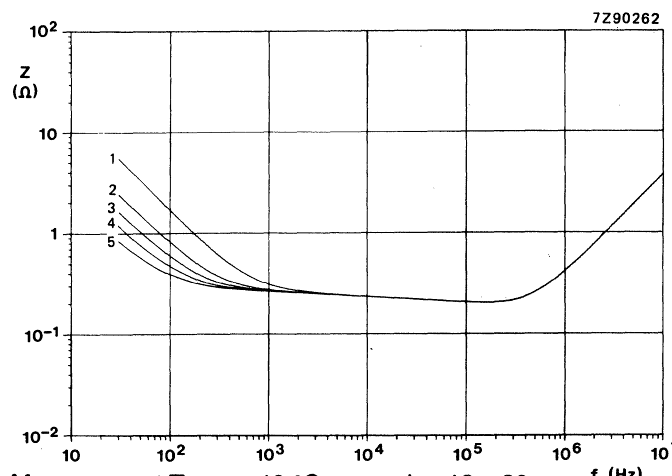


Fig.18 Typical impedance as a function of frequency at T_{amb} = –40 °C, case size 18 x 30.

Curve 1 : 1000 µF-63 V
Curve 2 : 2200 µF-40 V
Curve 3 : 3300 µF-25 V
Curve 4 : 4700 µF-16 V
Curve 5 : 6800 µF-10 V.

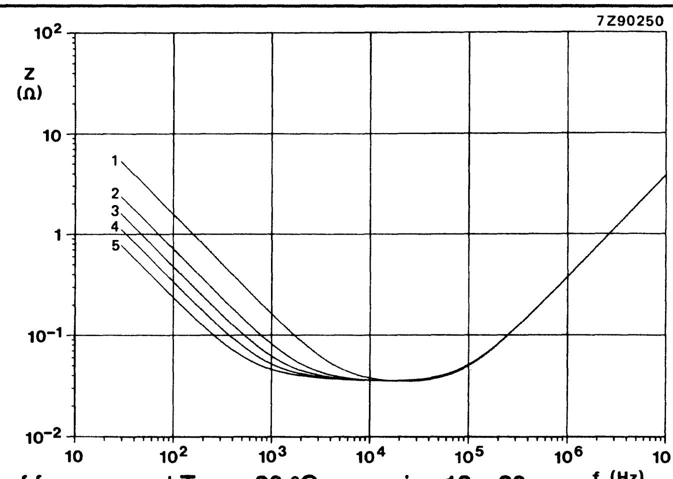
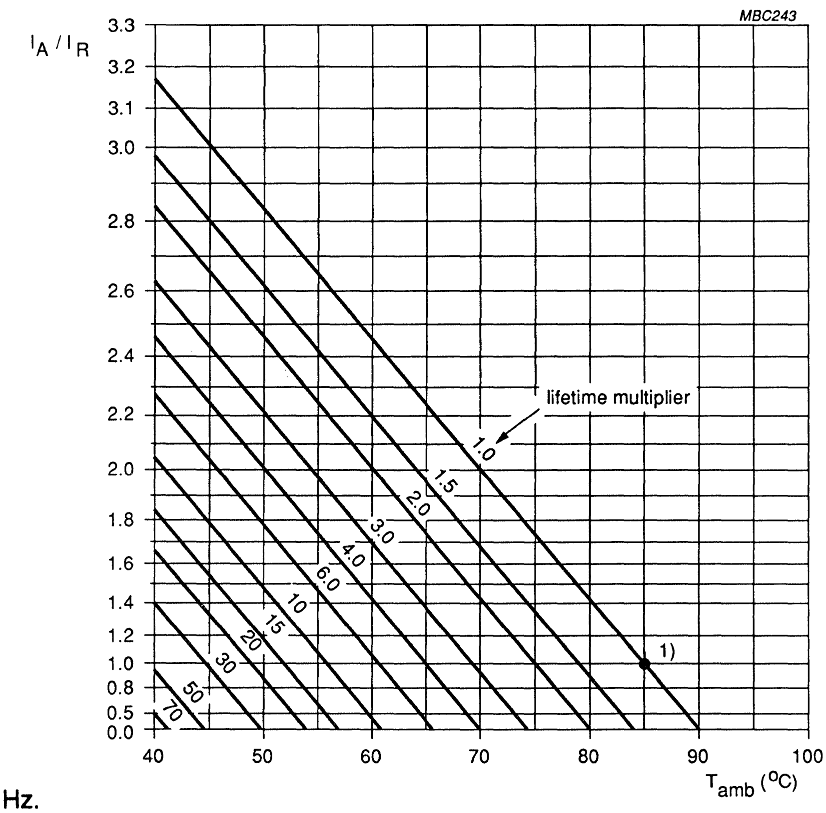


Fig.19 Typical impedance as a function of frequency at T_{amb} = 20 °C, case size 18 x 30.

RIPPLE CURRENT and USEFUL LIFE

Table 8 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency (I_{RO} = rated ripple current at 100 Hz and 85 °C)

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 to 16 V	U_R = 25 to 40 V	U_R = 63 to 100 V
50	0.95	0.9	0.85
100	1	1	1
300	1.07	1.12	1.2
1 000	1.12	1.2	1.3
3 000	1.15	1.25	1.35
≥10 000	1.2	1.3	1.4



I_A = actual ripple current at 100 Hz.
I_R = rated ripple current at 100 Hz, 85 °C.

Useful life at 85 °C and I_R applied:
case sizes 4.5 x 10 to 10 x 25: 2500 hours
case sizes 10 x 30 to 21 x 40: 8000 hours.

Fig.20 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 9

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 85 °C, U_R applied case sizes: 4.5 x 10 to 10 x 25 U_R = 6.3 to 25 V: 1000 hours U_R = 40 to 100 V: 2000 hours 10 x 30 to 21 x 40 U_R = 6.3 to 100 V: 5000 hours	U_R ≤6.3 V : ΔC/C +15/–30% U_R >6.3 V : ΔC/C ±15% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied case sizes: 4.5 x 10 to 10 x 25: 2500 hours 10 x 30 to 21 x 40: 8000 hours	U_R ≤6.3 V : ΔC/C +45/–50% U_R >6.3 V : ΔC/C ±45% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤1%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above

Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Axial leads,
  cylindrical aluminium case,
  insulated with a blue sleeve
- Mounting ring version (single ended) not insulated
- Case sizes 10 x 30 to 21 x 40 with safety vent
- Taped version available for automatic insertion up to 15 x 30
- Charge and discharge proof
- Useful life: 3000/8000 hours at 85 °C
  (case ∅ 3.3 mm: 1500 hours)
- Standard dimensions.

APPLICATIONS

- General purpose and industrial, automotive, telecommunication, audio-video
- Coupling, decoupling, timing, smoothing, filtering, buffering in SMPS
- Boards with restricted mounting height, vibration and shock resistant.

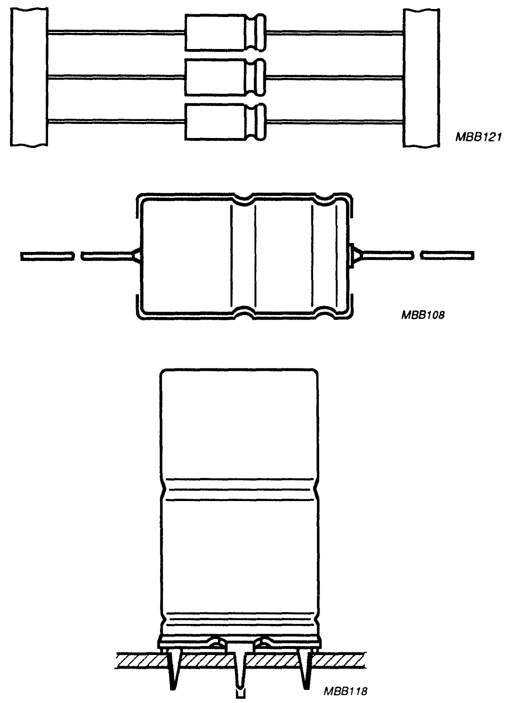


Fig.1 Component outlines.

QUICK REFERENCE DATA

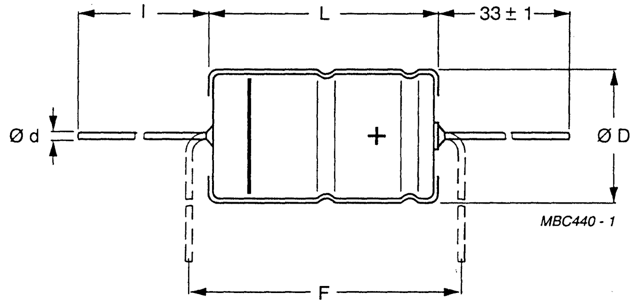
Case sizes (∅ D_{nom} x L_{nom} in mm)	3.3 x 11	4.5 x 10 to 10 x 25	10 x 30 to 21 x 40
Rated capacitance range, C_R	0.33 to 15 000 µF		
Tolerance on C_R	−10 to +50%		
Rated voltage range, U_R	6.3 to 100 V		
Category temperature range	−40 to +85 °C		
Endurance test at 85 °C	1000 hours	2000 hours	5000 hours
Useful life at 85 °C	1500 hours	3000 hours	8000 hours
Useful life at 40 °C, 1.4 I_R applied	40 000 hours	80 000 hours	200 000 hours
Shelf life at 0 V, 85 °C	500 hours		
Basic specification	IEC 384-4/ CECC 30 300 GP grade	IEC 384-4/CECC 30 300, LL grade	
Detail specification	DIN 41316 (6.3 to 63 V), DIN 41332 (100 V)		
Climatic category IEC 68 DIN 40040	 40/085/56 GPF		
Approvals		LNZ 44-04	

Table 1 Selection chart for $C_R U_R$ and relevant nominal case sizes (∅ **D x L** in **mm**) ∗ = preferred values

C_R (μF)	U_R (V)						
	6.3	**10**	**16**	**25**	**40**	**63**	**100**
0.33						4.5 x 10	
0.47						4.5 x 10∗ 3.3 x 11	4.5 x 10∗
1.0						4.5 x 10∗ 3.3 x 11	4.5 x 10∗
1.5						4.5 x 10	
2.2					3.3 x 11∗	4.5 x 10∗	4.5 x 10∗
3.3				3.3 x 11		4.5 x 10	4.5 x 10
4.7			3.3 x 11∗			4.5 x 10∗	6 x 10∗
6.8		3.3 x 11			4.5 x 10	4.5 x 10	6 x 10
10	3.3 x 11∗			4.5 x 10∗	4.5 x 10∗	6 x 10∗	8 x 11∗ 6.5 x 18∗
15			4.5 x 10		4.5 x 10	6 x 10	
22		4.5 x 10∗		4.5 x 10∗	6 x 10∗	8 x 11∗ 6.5 x 18∗	8 x 18∗
33	4.5 x 10		4.5 x 10		6 x 10		10 x 18
47		4.5 x 10∗		6 x 10∗	8 x 11∗ 6.5 x 18∗	8 x 18∗	10 x 25∗
68	4.5 x 10		6 x 10			10 x 18	10 x 30
100		6 x 10∗		8 x 11∗ 6.5 x 18∗	8 x 18∗	10 x 25∗	12.5 x 30∗
150	6 x 10		8 x 11 6.5 x 18	8 x 18	10 x 18	10 x 30	15 x 30
220		8 x 11∗ 6.5 x 18∗	8 x 18∗	10 x 18∗	10 x 25∗ 10 x 30∗	12.5 x 30∗	18 x 30∗
330		8 x 18∗	10 x 18∗	10 x 25∗	12.5 x 30∗	15 x 30∗	18 x 40∗
470	8 x 18∗	10 x 18∗	10 x 25∗	10 x 30∗	12.5 x 30∗	15 x 30∗	21 x 40∗
680	10 x 18∗	10 x 25∗	10 x 30∗	12.5 x 30∗	15 x 30∗	18 x 30∗	21 x 40∗
1000	10 x 25∗	10 x 30∗	12.5 x 30∗	15 x 30∗	18 x 30∗	21 x 40∗	
1500	10 x 30∗	12.5 x 30∗	15 x 30∗	18 x 30∗	18 x 40∗	21 x 40∗	
2200	12.5 x 30∗	15 x 30∗	18 x 30∗	18 x 40∗	21 x 40∗		
3300	15 x 30∗	18 x 30∗	18 x 40∗	21 x 40∗	21 x 40∗		
4700	18 x 30∗	18 x 40∗	21 x 40∗	21 x 40∗			
6800	18 x 40∗	21 x 40∗	21 x 40∗				
10 000	21 x 40∗	21 x 40∗					
15 000	21 x 40∗						

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.



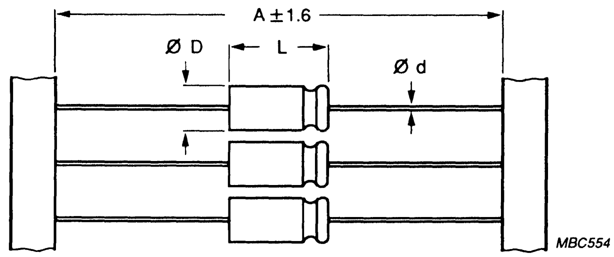
For case sizes 18 x 40 and 21 x 40, the stated L may be exceeded by 0.7 mm.

Fig.2 Case sizes 10 x 30 to 21 x 40 **Form AA**: axial; for dimensions see Table 2.

Table 2 Axial, dimensions in mm; mass in g

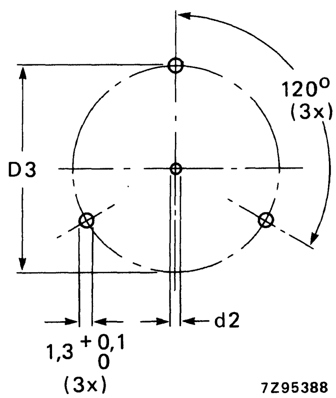
CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	AXIAL: Form AA, BA, and BR						APPROX. MASS	PACKING QUANTITIES		
		Ød	l	A	ØD_{max}	L_{max}	F_{min}		Form AA	Form BA	Form BR
3.3 x 11	1	0.6	–	63.5 ±1.5	3.5	12	17.5	0.35	–	1000	4000
4.5 x 10	2	0.6	–	63.5 ±1.5	5.0	10.5	15	0.5	–	1000	3000
6 x 10	3	0.6	–	63.5 ±1.5	6.3	10.5	15	0.7	–	1000	1000
8 x 11	5a	0.6	–	63.5 ±1.5	8.5	11.5	15	1.1	–	500	500
6.5 x 18	4	0.8	–	73 ±1.6	6.9	18.5	25	1.3	–	1000	1000
8 x 18	5	0.8	–	73 ±1.6	8.5	18.5	25	1.7	–	500	500
10 x 18	6	0.8	–	73 ±1.6	10.5	18.5	25	2.5	–	500	500
10 x 25	7	0.8	–	73 ±1.6	10.5	25.0	30	3.3	–	500	500
10 x 30	00	0.8	55 ±1	73 ±1.6	10.5	30.5	35	4.8	200	–	500
12.5 x 30	01	0.8	55 ±1	73 ±1.6	13.0	30.5	35	7.4	200	–	400
15 x 30	02	0.8	55 ±1	73 ±1.6	15.5	30.5	35	11.7	200	–	250
18 x 30	03	0.8	55 ±1	–	18.5	30.5	35	12.9	200	–	–
18 x 40	04	0.8	34 ±1	–	18.5	41.5	45	19.4	100	–	–
21 x 40	05	0.8	34 ±1	–	21.5	41.5	45	24.7	100	–	–

Tape dimensions are specified in chapter "PACKING",

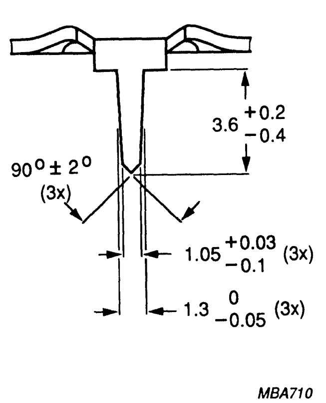


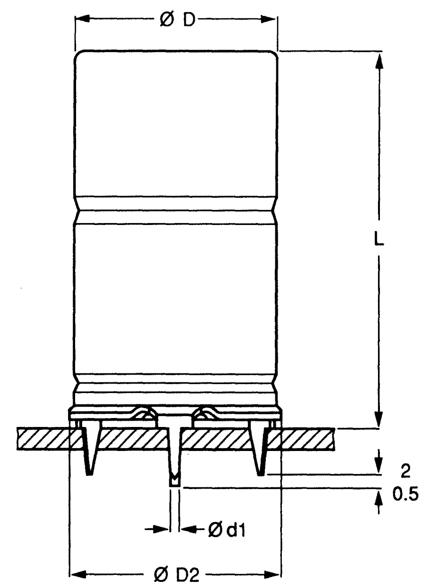
Form BR: Taped on reel, case sizes 3.3 x 11 to 15 x 30.
Form BA: Taped in box (ammopack), case sizes 3.3 x 11 to 10 x 25.

Fig.3 Case sizes 3.3 x 11 to 15 x 30, axial.



Piercing diagram.





Form MR: case not insulated (insulation on request).
Especially for applications with severe shocks and vibrations.

Fig.4 Case sizes 15 x 30 to 21 x 40, single ended with mounting ring and pins.

Table 3 Single ended, dimensions in mm; mass in g

CASE SIZE	CASE	SINGLE ENDED WITH MOUNTING RING: Form MR						APPROX.	PACKING
Ø D_{nom} x L_{nom}	CODE	Ød_1	Ød_2	ØD_{max}	Ø$D2_{max}$	D3	L_{max}	MASS	QUANTITIES
15 x 30	02	0.8	1.0 +0.1	15.5	17.5	16.5 ±0.2	33	11.7	200
18 x 30	03	0.8	1.0 +0.1	18.5	19.5	18.5 ±0.2	33	12.9	200
18 x 40	04	1.0	1.3 +0.1	18.5	19.5	18.5 ±0.2	45	19.4	100
21 x 40	05	1.0	1.3 +0.1	21.5	22.5	21.5 ±0.2	45	24.7	100

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 4 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz, tolerance −10 to +50%
I_R	= RMS ripple current at 100 Hz, 85 °C
I_{L1}	= max. leakage current after 1 minute at U_R
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	= max. impedance at 1 kHz or 10 kHz.

Table 4 Electrical data

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 1 kHz (Ω)	Z 10 kHz (Ω)
6.3	10	3.3 x 11	15	5	5	0.30	47.8		20
	33	4.5 x 10	50	11	5.4	0.25	12.1		6.1
	68	4.5 x 10	75	22	5.9	0.25	5.86		2.9
	150	6 x 10	120	10	6.9	0.25	2.66		1.3
	470	8 x 18	330	22	11	0.25	0.85		0.43
	680	10 x 18	430	30	14	0.25	0.59		0.29
	1000	10 x 25	560	42	18	0.25	0.40		0.20
	1500	10 x 30	450	61	24	0.28	0.30	0.23	
	2200	12.5 x 30	610	88	33	0.29	0.21	0.16	
	3300	15 x 30	790	129	47	0.32	0.15	0.11	
	4700	18 x 30	1000	182	64	0.34	0.12	0.07	
	6800	18 x 40	1280	261	91	0.39	0.09	0.05	
	10 000	21 x 40	1570	382	131	0.45	0.07	0.05	
	15 000	21 x 40	1600	571	194	0.67	0.07	0.05	

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitors 2222 031/032/033 . . . . .
1000 µF/10 V, −10/+50%
Case size 10 x 30; Form BR
Catalogue number: 2222 032 24102.

Table 5 Ordering information

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
6.3	10	3.3 x 11	1	–	030 23109	030 33109	–
	33	4.5 x 10	2	–	030 23339	030 33339	–
	68	4.5 x 10	2	–	030 23689	030 33689	–
	150	6 x 10	3	–	030 23151	030 33151	–
	470	8 x 18	5	–	031 23471	031 33471	–
	680	10 x 18	6	–	031 23681	031 33681	–
	1000	10 x 25	7	–	031 23102	031 33102	–
	1500	10 x 30	00	032 13152	032 23152	–	–
	2200	12.5 x 30	01	032 13222	032 23222	–	–
	3300	15 x 30	02	032 13332	032 23332	–	032 43332
	4700	18 x 30	03	032 13472	–	–	032 43472
	6800	18 x 40	04	033 13682	–	–	033 43682
	10 000	21 x 40	05	033 13103	–	–	033 43103
	15 000	21 x 40	05	033 13153	–	–	033 43153

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 1 kHz (Ω)	Z 10 kHz (Ω)
10	6.8	3.3 x 11	15	5	5	0.25	58.6		24
	22	4.5 x 10	45	11	5.4	0.20	14.5		7.3
	47	4.5 x 10	70	24	5.9	0.20	6.78		3.4
	100	6 x 10	110	110	7	0.20	3.19		1.6
	220	8 x 11	210	18	9.4	0.20	1.45		0.73
	220	6.5 x 18	210	18	9.4	0.20	1.45		0.73
	330	8 x 18	310	24	12	0.20	0.97		0.48
	470	10 x 18	410	33	14	0.20	0.68		0.34
	680	10 x 25	510	45	19	0.20	0.47		0.24
	1000	10 x 30	430	64	25	0.20	0.32		0.20
	1500	12.5 x 30	570	94	35	0.23	0.25	0.20	
	2200	15 x 30	740	136	49	0.24	0.18	0.14	
	3300	18 x 30	950	202	71	0.27	0.13	0.09	
	4700	18 x 40	1220	286	99	0.29	0.10	0.06	
	6800	21 x 40	1500	412	141	0.34	0.08	0.04	
	10 000	21 x 40	1520	604	205	0.49	0.08	0.05	
16	4.7	3.3 x 11	15	5	5	0.20	67.8		26
	15	4.5 x 10	55	12	5.5	0.16	17.0		8
	33	4.5 x 10	65	27	6.1	0.16	7.72		3.6
	68	6 x 10	110	11	7.2	0.16	3.75		1.8
	150	8 x 11	200	19	9.8	0.16	1.70		0.80
	150	6.5 x 18	200	19	9.8	0.16	1.70		0.80
	220	8 x 18	270	26	12	0.16	1.16		0.55
	330	10 x 18	410	36	16	0.16	0.78		0.36
	470	10 x 25	480	49	20	0.16	0.55		0.26
	680	10 x 30	400	70	27	0.16	0.38		0.18
	1000	12.5 x 30	550	100	37	0.16	0.26		0.12
	1500	15 x 30	680	148	53	0.19	0.21	0.17	
	2200	18 x 30	880	216	75	0.20	0.15	0.13	
	3300	18 x 40	1160	321	111	0.23	0.11	0.08	
	4700	21 x 40	1430	455	155	0.25	0.09	0.06	
	6800	21 x 40	1460	657	223	0.36	0.08	0.06	

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
10	6.8	3.3 x 11	1	–	030 24688	030 34688	–
	22	4.5 x 10	2	–	030 24229	030 34229	–
	47	4.5 x 10	2	–	030 24479	030 34479	–
	100	6 x 10	3	–	030 24101	030 34101	–
	220	8 x 11	5a	–	030 24221	030 34221	–
	220	6.5 x 18	4	–	031 24221	031 34221	–
	330	8 x 18	5	–	031 24331	031 34331	–
	470	10 x 18	6	–	031 24471	031 34471	–
	680	10 x 25	7	–	031 24681	031 34681	–
	1000	10 x 30	00	032 14102	032 24102	–	–
	1500	12.5 x 30	01	032 14152	032 24152	–	–
	2200	15 x 30	02	032 14222	032 24222	–	032 44222
	3300	18 x 30	03	032 14332	–	–	032 44332
	4700	18 x 40	04	033 14472	–	–	033 44472
	6800	21 x 40	05	033 14682	–	–	033 44682
	10 000	21 x 40	05	033 14103	–	–	033 44103
16	4.7	3.3 x 11	1	–	030 25478	030 35478	–
	15	4.5 x 10	2	–	030 25159	030 35159	–
	33	4.5 x 10	2	–	030 25339	030 35339	–
	68	6 x 10	3	–	030 25689	030 35689	–
	150	8 x 11	5a	–	030 25151	030 35151	–
	150	6.5 x 18	4	–	031 25151	031 35151	–
	220	8 x 18	5	–	031 25221	031 35221	–
	330	10 x 18	6	–	031 25331	031 35331	–
	470	10 x 25	7	–	031 25471	031 35471	–
	680	10 x 30	00	032 15681	032 25681	–	–
	1000	12.5 x 30	01	032 15102	032 25102	–	–
	1500	15 x 30	02	032 15152	032 25152	–	032 45152
	2200	18 x 30	03	032 15222	–	–	032 45222
	3300	18 x 40	04	033 15332	–	–	033 45332
	4700	21 x 40	05	033 15472	–	–	033 45472
	6800	21 x 40	05	033 15682	–	–	033 45682

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 1 kHz (Ω)	Z 10 kHz (Ω)
25	3.3	3.3 x 11	15	5	5	0.18	86.9		27
	10	4.5 x 10	50	13	5.5	0.14	22.3		9
	22	4.5 x 10	60	28	6.1	0.14	10.2		4.1
	47	6 x 10	100	12	7.4	0.14	4.8		1.9
	100	8 x 11	160	19	10	0.14	2.23		0.90
	100	6.5 x 18	160	19	10	0.14	2.23		0.90
	150	8 x 18	240	27	13	0.14	1.49		0.60
	220	10 x 18	350	37	16	0.14	1.02		0.41
	330	10 x 25	460	54	22	0.14	0.68		0.27
	470	10 x 30	360	75	29	0.14	0.47		0.19
	680	12.5 x 30	500	106	39	0.14	0.32		0.13
	1000	15 x 30	660	154	55	0.14	0.22		0.09
	1500	18 x 30	810	229	80	0.17	0.18	0.15	
	2200	18 x 40	1060	334	115	0.18	0.13	0.10	
	3300	21 x 40	1340	499	170	0.21	0.10	0.07	
	4700	21 x 40	1370	709	240	0.28	0.10	0.06	
40	2.2	3.3 x 11	15	5	5	0.15	109		32
	6.8	4.5 x 10	45	14	5.5	0.11	25.8		10
	10	4.5 x 10	50	20	5.8	0.11	17.6		7
	15	4.5 x 10	55	30	6.2	0.11	11.7		4.7
	22	6 x 10	75	9	6.8	0.11	8.0		3.2
	33	6 x 10	95	12	7.7	0.11	5.31		2.1
	47	8 x 11	150	16	8.8	0.11	3.73		1.5
	47	6.5 x 18	150	16	8.8	0.11	3.73		1.5
	100	8 x 18	220	28	13	0.11	1.75		0.70
	150	10 x 18	300	40	17	0.11	1.17		0.47
	220	10 x 25	430	57	23	0.11	0.80		0.32
	220	10 x 30	260	57	23	0.12	0.86		0.32
	330	12.5 x 30	370	84	31	0.12	0.58		0.21
	470	12.5 x 30	440	117	43	0.12	0.40		0.15
	680	15 x 30	580	167	59	0.12	0.28		0.10
	1000	18 x 30	780	244	85	0.12	0.19		0.07
	1500	18 x 40	970	364	125	0.15	0.16	0.13	
	2200	21 x 40	1220	532	181	0.16	0.12	0.09	
	3300	21 x 40	1284	796	269	0.24	0.11	0.07	

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
25	3.3	3.3 x 11	1	–	030 26338	030 36338	–
	10	4.5 x 10	2	–	030 26109	030 36109	–
	22	4.5 x 10	2	–	030 26229	030 36229	–
	47	6 x 10	3	–	030 26479	030 36479	–
	100	8 x 11	5a	–	030 26101	030 36101	–
	100	6.5 x 18	4	–	031 26101	031 36101	–
	150	8 x 18	5	–	031 26151	031 36151	–
	220	10 x 18	6	–	031 26221	031 36221	–
	330	10 x 25	7	–	031 26331	031 36331	–
	470	10 x 30	00	032 16471	032 26471	–	–
	680	12.5 x 30	01	032 16681	032 26681	–	–
	1000	15 x 30	02	032 16102	032 26102	–	032 46102
	1500	18 x 30	03	032 16152	–	–	032 46152
	2200	18 x 40	04	033 16222	–	–	033 46222
	3300	21 x 40	05	033 16332	–	–	033 46332
	4700	21 x 40	05	033 16472	–	–	033 46472
40	2.2	3.3 x 11	1	–	030 27228	030 37228	–
	6.8	4.5 x 10	2	–	030 27688	030 37688	–
	10	4.5 x 10	2	–	030 27109	030 37109	–
	15	4.5 x 10	2	–	030 27159	030 37159	–
	22	6 x 10	3	–	030 27229	030 37229	–
	33	6 x 10	3	–	030 27339	030 37339	–
	47	8 x 11	5a	–	030 27479	030 37479	–
	47	6.5 x 18	4	–	031 27479	031 37479	–
	100	8 x 18	5	–	031 27101	031 37101	–
	150	10 x 18	6	–	031 27151	031 37151	–
	220	10 x 25	7	–	031 27221	031 37221	–
	220	10 x 30	00	032 17221	032 27221	–	–
	330	12.5 x 30	01	032 17331	032 27331	–	–
	470	12.5 x 30	01	032 17471	032 27471	–	–
	680	15 x 30	02	032 17681	032 27681	–	032 47681
	1000	18 x 30	03	032 17102	–	–	032 47102
	1500	18 x 40	04	033 17152	–	–	033 47152
	2200	21 x 40	05	033 17222	–	–	033 47222
	3300	21 x 40	05	033 17332	–	–	033 47332

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 1 kHz (Ω)	Z 10 kHz (Ω)
63	0.33	4.5 x 10	4	5	5	0.09	435		167
	0.47	3.3 x 11	6	5	5	0.10	339		117
	0.47	4.5 x 10	6	5	5	0.09	305		117
	1.0	3.3 x 11	10	5	5	0.12	191		55
	1.0	4.5 x 10	13	5	5	0.09	143		55
	1.5	4.5 x 10	17	5	5	0.09	95.6		37
	2.2	4.5 x 10	25	7	5.3	0.09	65.2		25
	3.3	4.5 x 10	35	11	5.4	0.09	46.5		17
	4.7	4.5 x 10	40	15	5.6	0.09	30.5		12
	6.8	4.5 x 10	46	22	5.9	0.09	21.1		8.1
	10	6 x 10	70	7	6.3	0.08	12.8		5.5
	15	6 x 10	79	10	6.9	0.08	8.5		3.7
	22	8 x 11	110	13	7.8	0.08	5.79		2.5
	22	6.5 x 18	110	13	7.8	0.08	5.79		2.5
	47	8 x 18	190	22	11	0.08	2.71		1.2
	68	10 x 18	250	30	14	0.08	1.88		0.81
	100	10 x 25	300	42	18	0.08	1.28		0.55
	150	10 x 30	260	61	24	0.08	0.90		0.37
	220	12.5 x 30	350	88	33	0.08	0.61		0.25
	330	15 x 30	480	129	47	0.08	0.41		0.17
	470	15 x 30	570	182	64	0.08	0.29		0.15
	680	18 x 30	770	261	91	0.08	0.20		0.08
	1000	21 x 40	1140	382	131	0.08	0.14		0.06
	1500	21 x 40	1110	571	194	0.12	0.15	0.15	

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U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
63	0.33	4.5 x 10	2	–	030 28337	030 38337	–
	0.47	3.3 x 11	1	–	030 90065	030 90098	–
	0.47	4.5 x 10	2	–	030 28477	030 38477	–
	1.0	3.3 x 11	1	–	030 90067	030 90068	–
	1.0	4.5 x 10	2	–	030 28108	030 38108	–
	1.5	4.5 x 10	2	–	030 28158	030 38158	–
	2.2	4.5 x 10	2	–	030 28228	030 38228	–
	3.3	4.5 x 10	2	–	030 28338	030 38338	–
	4.7	4.5 x 10	2	–	030 28478	030 38478	–
	6.8	4.5 x 10	2	–	030 28688	030 38688	–
	10	6 x 10	3	–	030 28109	030 38109	–
	15	6 x 10	3	–	030 28159	030 38159	–
	22	8 x 11	5a	–	030 28229	030 38229	–
	22	6.5 x 18	4	–	031 28229	031 38229	–
	47	8 x 18	5	–	031 28479	031 38479	–
	68	10 x 18	6	–	031 28689	031 38689	–
	100	10 x 25	7	–	031 28101	031 38101	–
	150	10 x 30	00	032 18151	032 28151	–	–
	220	12.5 x 30	01	032 18221	032 28221	–	–
	330	15 x 30	02	032 18331	032 28331	–	032 48331
	470	15 x 30	02	032 18471	032 28471	–	032 48471
	680	18 x 30	03	032 18681	–	–	032 48681
	1000	21 x 40	05	033 18102	–	–	033 48102
	1500	21 x 40	05	033 18152	–	–	033 48152

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 1 kHz (Ω)	Z 10 kHz (Ω)
100	0.47	4.5 x 10	9	5	5	0.08	271		96
	1.0	4.5 x 10	20	5	5	0.08	128		45
	2.2	4.5 x 10	30	11	11	0.08	57.9		21
	3.3	4.5 x 10	40	17	17	0.08	38.6		14
	4.7	6 x 10	50	22	22	0.07	23.7		9.6
	6.8	6 x 10	70	34	34	0.07	16.4		6.6
	10	8 x 11	90	50	50	0.07	11.2		4.5
	10	6.5 x 18	90	50	50	0.07	11.2		4.5
	22	8 x 18	120	80	80	0.07	5.07		2.1
	33	10 x 18	200	119	119	0.07	3.38		1.4
	47	10 x 25	260	33	33	0.07	2.37		0.96
	68	10 x 30	130	45	45	0.15	3.53		2.0
	100	12.5 x 30	190	64	64	0.15	2.40		1.2
	150	15 x 30	250	94	94	0.15	1.60		0.85
	220	18 x 30	330	136	136	0.15	1.09		0.60
	330	18 x 40	460	202	202	0.15	0.73		0.50
	470	21 x 40	600	286	286	0.15	0.51		0.35
	680	21 x 40	650	412	412	0.15	0.42		0.35

Voltage

Surge voltage for short periods	$U_s \leq 1.15 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R

case sizes 3.3 x 11 and 4.5 x 10	$I_{L1} \leq 0.05\ C_R \times U_R$ or 5 μA, whichever is greater
case sizes 6 x 10 to 21 x 40	I_{L1} for CU ≤ 1000 μC: ≤ $0.01\ C_R \times U_R$ or 1 μA, whichever is greater I_{L1} for CU > 1000 μC: ≤ $0.006\ C_R \times U_R + 4$ μA

After 5 minutes at U_R

6.3 to 63 V	$I_{L5} \leq 0.002\ C_R \times U_R + 5$ μA
100 V	$I_{L5} \leq 0.006\ C_R \times U_R + 4$ μA

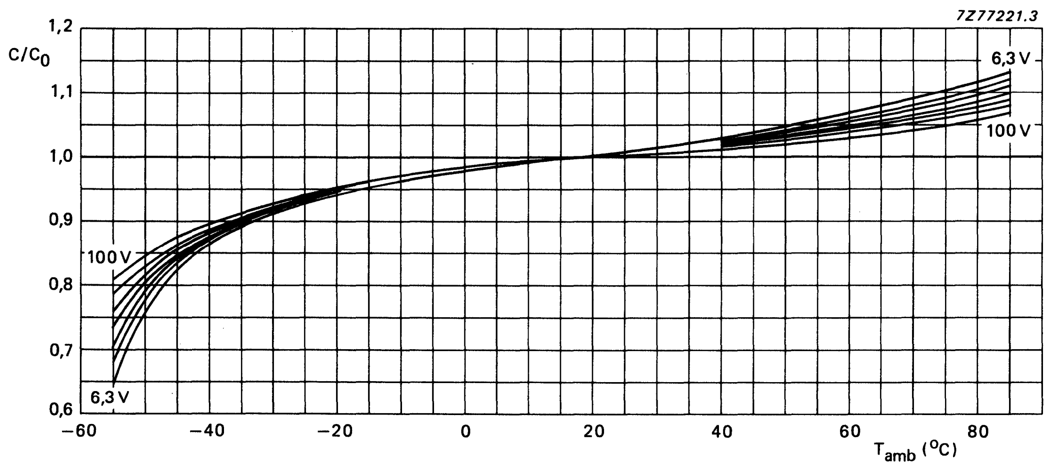
U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
100	0.47	4.5 x 10	2	–	030 29477	030 39477	–
	1.0	4.5 x 10	2	–	030 29108	030 39108	–
	2.2	4.5 x 10	2	–	030 29228	030 39228	–
	3.3	4.5 x 10	2	–	030 29338	030 39338	–
	4.7	6 x 10	3	–	030 29478	030 39478	–
	6.8	6 x 10	3	–	030 29688	030 39688	–
	10	8 x 11	5a	–	030 29109	030 39109	–
	10	6.5 x 18	4	–	031 29109	031 39109	–
	22	8 x 18	5	–	031 29229	031 39229	–
	33	10 x 18	6	–	031 29339	031 39339	–
	47	10 x 25	7	–	031 29479	031 39479	–
	68	10 x 30	00	032 19689	032 29689	–	–
	100	12.5 x 30	01	032 19101	032 29101	–	–
	150	15 x 30	02	032 19151	032 29151	–	032 49151
	220	18 x 30	03	032 19221	–	–	032 49221
	330	18 x 40	04	033 19331	–	–	033 49331
	470	21 x 40	05	033 19471	–	–	033 49471
	680	21 x 40	05	033 19681	–	–	033 49681

MARKING

The capacitors are marked (where possible) with the following information:

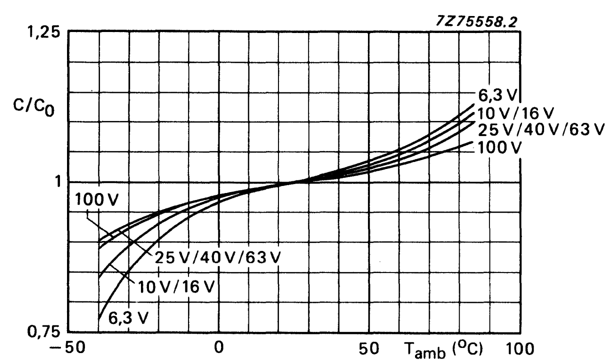
- Rated capacitance in µF
- Tolerance on rated capacitance, code letter in accordance with IEC 62 (not for case size 1)
- Rated voltage in V
- Group number (030, 031, 032 or 033)
- Code indicating factory of origin
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Band to identify the negative terminal
- "+" - signs to identify the positive terminal (not for case sizes L <18 mm).

Capacitance (C)



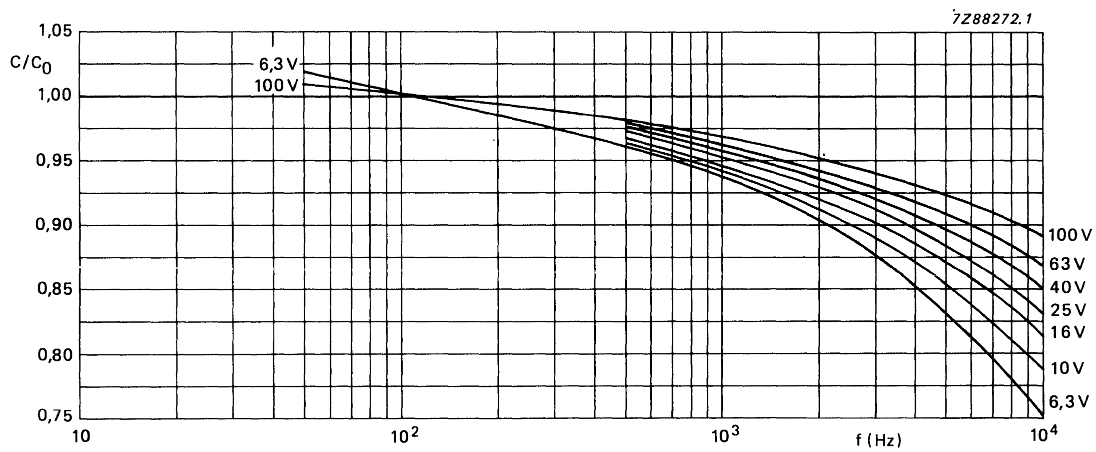
C_0 = capacitance at 20 °C, 100 Hz.

Fig.5 Multiplier of capacitance (C/C_0) as a function of ambient temperature; case sizes 3.3 x 11 to 10 x 25.



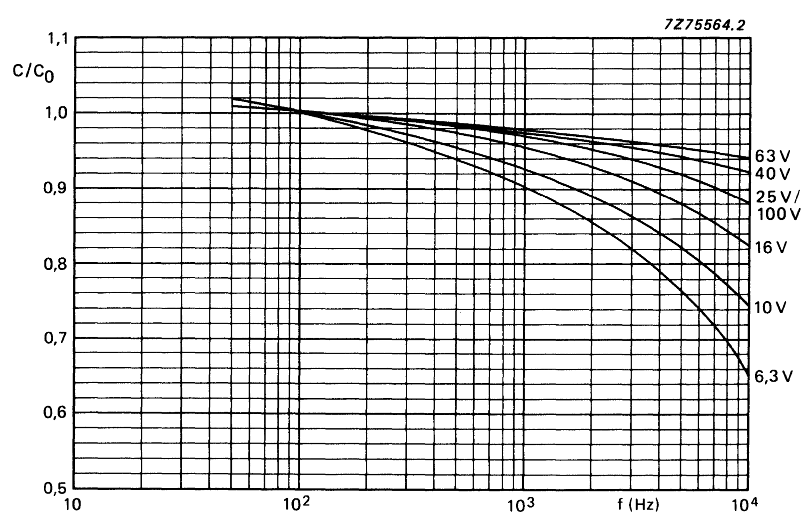
C_0 = capacitance at 20 °C, 100 Hz.

Fig.6 Multiplier of capacitance (C/C_0) as a function of ambient temperature; case sizes 10 x 30 to 21 x 40.



C_0 = capacitance at 20 °C, 100 Hz.

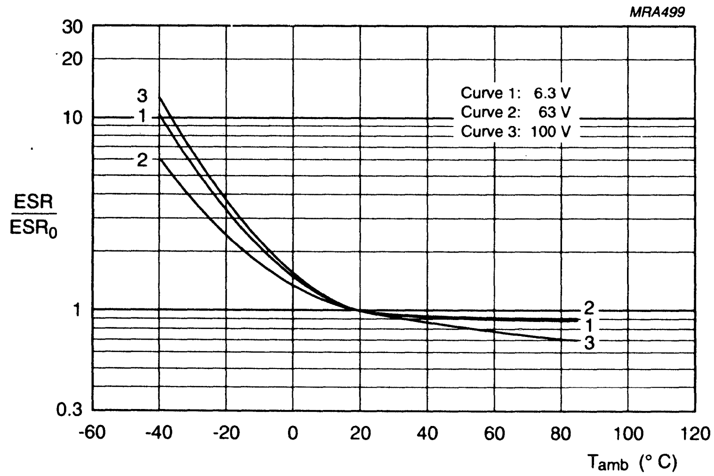
Fig.7 Multiplier of capacitance (C/C_0) as a function of frequency; case sizes 3.3 x 11 to 10 x 25.



C_0 = capacitance at 20 °C, 100 Hz.

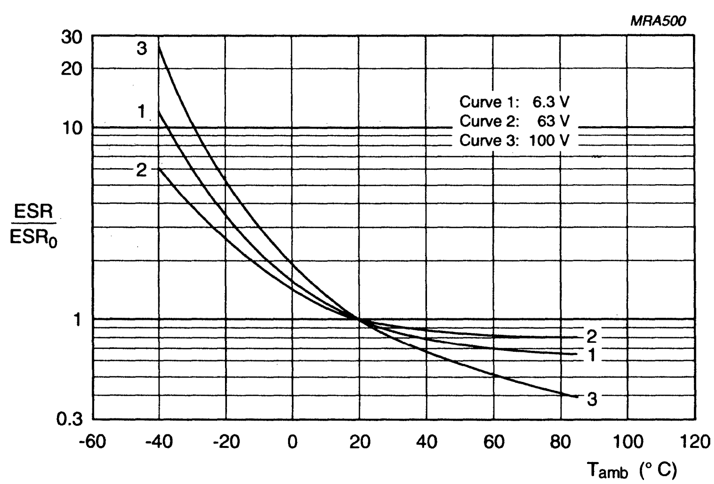
Fig.8 Multiplier of capacitance (C/C_0) as a function of frequency; case sizes 10 x 30 to 21 x 40.

Equivalent series resistance (ESR)



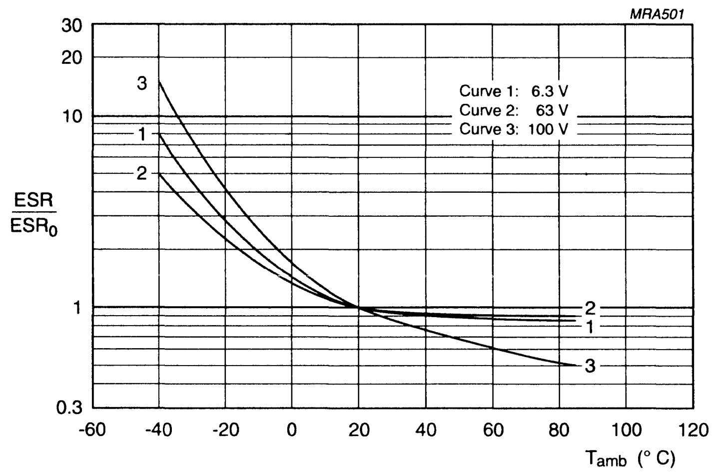
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.9 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; case sizes 3.3 x 11 to 10 x 25.



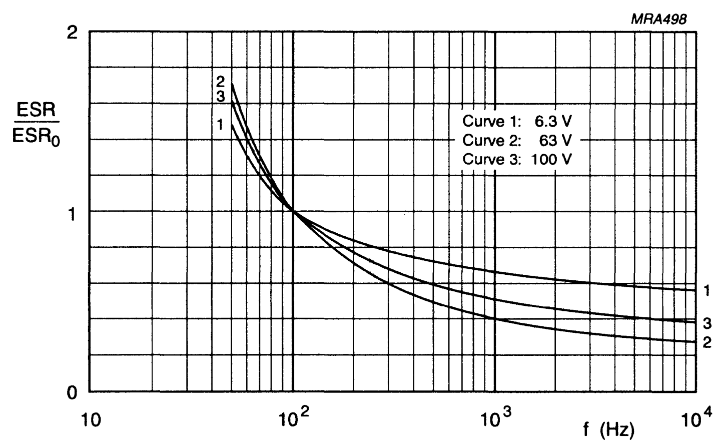
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.10 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; case sizes 10 x 30, 12.5 x 30 and 15 x 30.



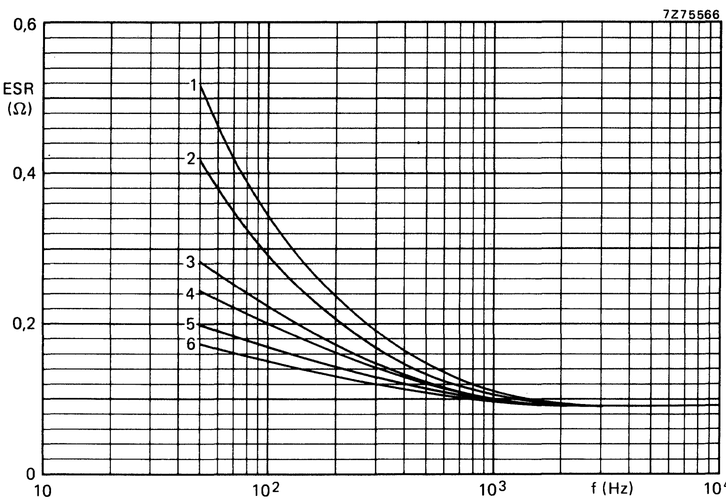
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.11 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; case sizes 18 x 30, 18 x 40 and 21 x 40.



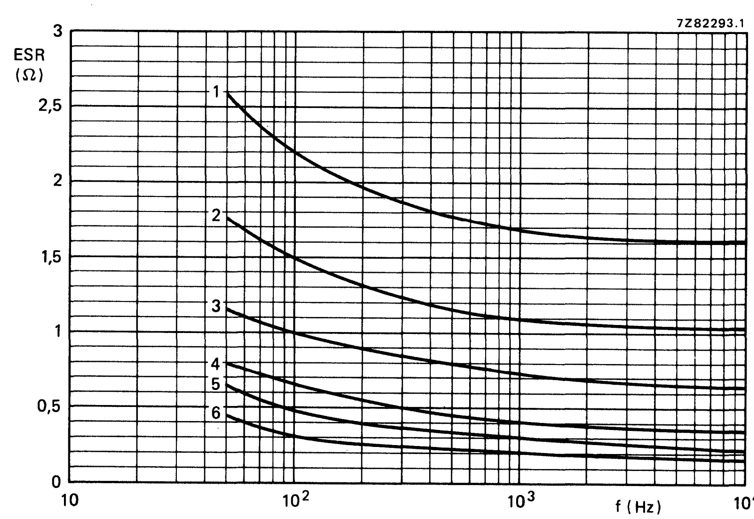
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.12 Multiplier of ESR (ESR/ESR_0) as a function of frequency; case sizes 3.3 x 11 to 10 x 25.



Curve 1: 220 µF - 63 V
Curve 2: 330 µF - 40 V
Curve 3: 470 µF - 40 V
Curve 4: 680 µF - 25 V
Curve 5: 1000 µF - 16 V
Curve 6: 1500 µF - 10 V and 2200 µF - 6.3 V.

Fig.13 Typical ESR as a function of frequency at 20 °C; case size 12.5 x 30; 6.3 to 63 V types.



Curve 1: 68 µF - case size 10 x 30
Curve 2: 100 µF - case size 12.5 x 30
Curve 3: 150 µF - case size 15 x 30
Curve 4: 220 µF - case size 18 x 30
Curve 5: 330 µF - case size 18 x 40
Curve 6: 470 µF and 680 µF - case size 21 x 40.

Fig.14 Typical ESR as a function of frequency at 20 °C; 100 V types.

Equivalent series inductance (ESL)

Table 6 Equivalent series inductance, typical values

CASE SIZE (∅ x L) (mm)	AXIAL (nH)	SINGLE ENDED (nH)
3.3 x 11	11	
4.5 x 10	10	
6 x 10	22	
8 x 11	85	
6.5 x 18	25	
8 x 18	40	
10 x 18	61	
10 x 25	38	
10 x 30	38	
12.5 x 30	46	
15 x 30	48	39
18 x 30	50	39
18 x 40	54	39
21 x 40	59	39

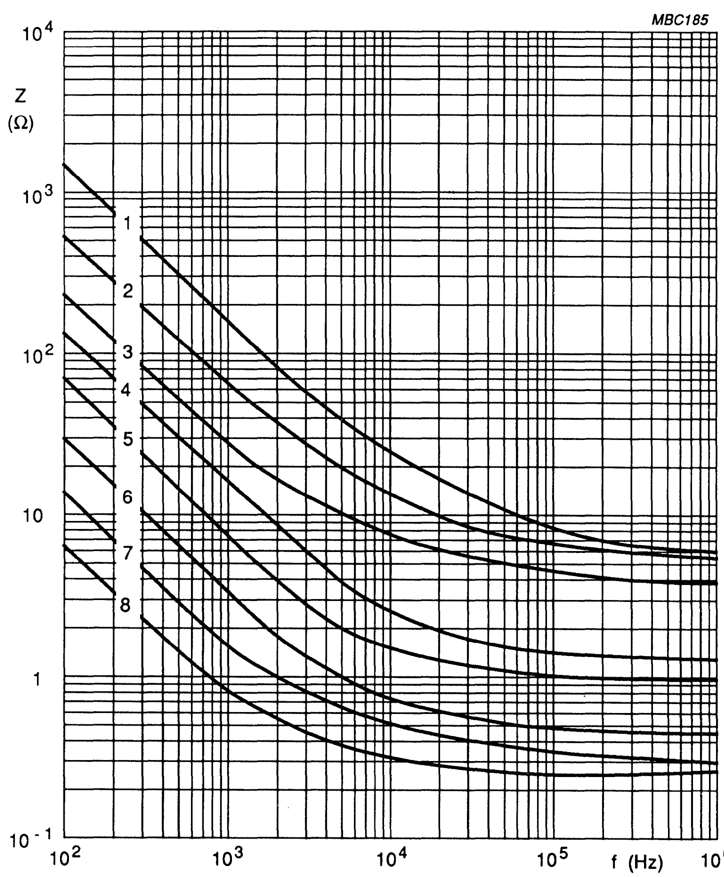
Impedance (Z)

Table 7 Impedance x capacitance values at 10 kHz

T_{amb}	$z = Z \times C_R (\Omega\ \mu F)$ at 10 kHz						
	6.3 V	10 V	16 V	25 V	40 V	63 V	100 V
+20 °C	≤ 200	≤ 160	≤ 120	≤ 90	≤ 70	≤ 55	≤ 45
–25 °C	≤1200	≤ 750	≤ 560	≤ 400	≤ 300	≤ 180	≤ 130
–40 °C	≤3200	≤2000	≤1500	≤1100	≤ 900	≤ 500	≤ 350

Table 8 Impedance x capacitance values at 1 kHz

T_{amb}	$z = Z \times C_R (\Omega\ \mu F)$ at 1 kHz						
	6.3 V	10 V	16 V	25 V	40 V	63 V	100 V
+20 °C	≤ 350	≤ 300	≤ 250	≤ 220	≤ 200	≤ 180	≤ 175
–25 °C	≤1700	≤1100	≤ 800	≤ 570	≤ 430	≤ 330	≤ 300
–40 °C	≤4500	≤2800	≤2000	≤1400	≤1100	≤ 800	–



Curve 1: 1 μF - 63 V - case size 3.3 x 11
Curve 2: 2.2 μF - 40 V
Curve 3: 4.7 μF - 16 V
Curve 4: 10 μF - 25 V
Curve 5: 22 μF - 25 V
Curve 6: 47 μF - 25 V
Curve 7: 100 μF - 25 V - case size 6.5 x 18
Curve 8: 220 μF - 10 V - case size 6.5 x 18.

Fig.15 Typical impedance as a function of frequency at 20 °C; case sizes 3.3 x 11 to 6.5 x 18.

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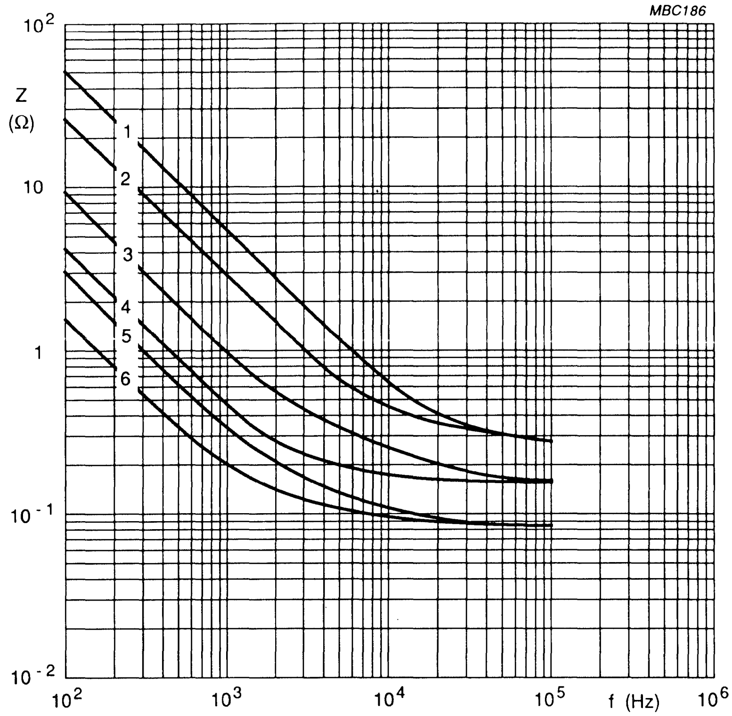
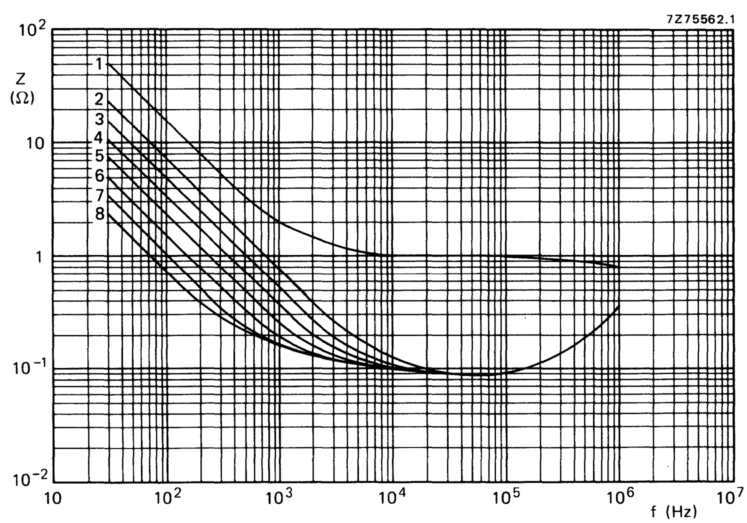


Curve 1: 22 µF - 63 V - case size 8 x 11
Curve 2: 47 µF - 40 V - case size 8 x 11
Curve 3: 150 µF - 25 V
Curve 4: 330 µF - 16 V
Curve 5: 470 µF - 16 V
Curve 6: 1000 µF - 6.3 V.

Fig.16 Typical impedance as a function of frequency at 20 °C; case sizes 8 x 11 to 10 x 25.



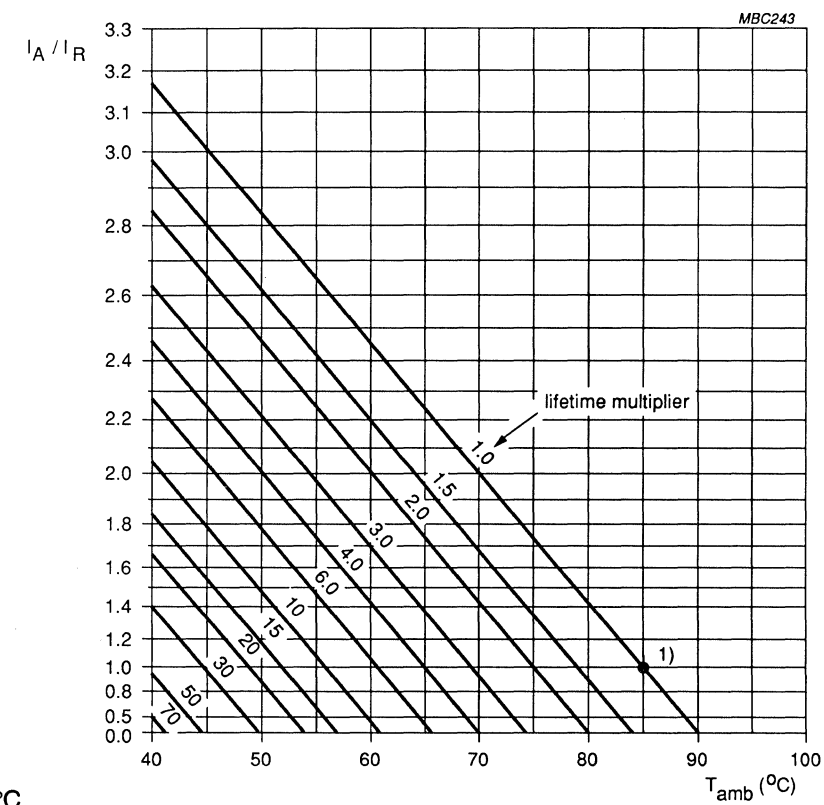
Curve 1: 100 µF - 100 V
Curve 2: 220 µF - 63 V
Curve 3: 330 µF - 40 V
Curve 4: 470 µF - 40 V
Curve 5: 680 µF - 25 V
Curve 6: 1000 µF - 16 V
Curve 7: 1500 µF - 10 V
Curve 8: 2200 µF - 6.3 V.

Fig.17 Typical impedance as a function of frequency at 20 °C; case size 12.5 x 30.

RIPPLE CURRENT and USEFUL LIFE

Table 9 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 85 °C, 100 Hz.

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 to 10 V	U_R = 16 to 25 V	U_R = 40 to 100 V
50	0.95	0.9	0.85
100	1.0	1.0	1.0
300	1.07	1.12	1.2
1000	1.12	1.2	1.3
3000	1.15	1.25	1.35
≥10 000	1.2	1.3	1.4



I_A = actual ripple current at 100 Hz.
I_R = rated ripple current at 100 Hz, 85 °C.

1) Useful life at 85 °C and I_R applied:
case size 3.3 x 11; 1500 hours
case size 4.5 x 10 to 10 x 25; 3000 hours
case size 10 x 30 to 21 x 40; 8000 hours.

Fig.18 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements".

Table 10 Case size 3.3 x 11

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 85 °C, U_R applied 1000 hours	ΔC/C ±20% tan δ ≤2 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied 1500 hours	ΔC/C ±50% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤3%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

Table 11 Case sizes 4.5 x 10 to 21 x 40

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 85 °C, U_R applied case sizes: 4.5 x 10 to 10 x 25: 2000 hours 10 x 30 to 21 x 40: 5000 hours	U_R ≤6.3 V : ΔC/C +15/−30% U_R >6.3 V : ΔC/C ±15% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied case sizes: 4.5 x 10 to 10 x 25: 3000 hours 10 x 30 to 21 x 40: 8000 hours	U_R ≤6.3 V : ΔC/C +45/−50% U_R >6.3 V : ΔC/C ±45% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤1%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Axial leads, cylindrical aluminium case, insulated with a blue sleeve
- Mounting ring version (single ended) not insulated
- Case sizes 10 x 30 to 21 x 40 with safety vent
- Taped versions up to 15 x 30 available for automatic insertion
- Charge and discharge proof
- Useful life: 5000/10 000 hours at 85 °C
- High rated voltage: up to 450 V.

APPLICATIONS

- General purpose, industrial, power supply, audio-video and lighting
- Smoothing, filtering, buffering at high voltages
- Boards with restricted mounting height, vibration and shock resistant.

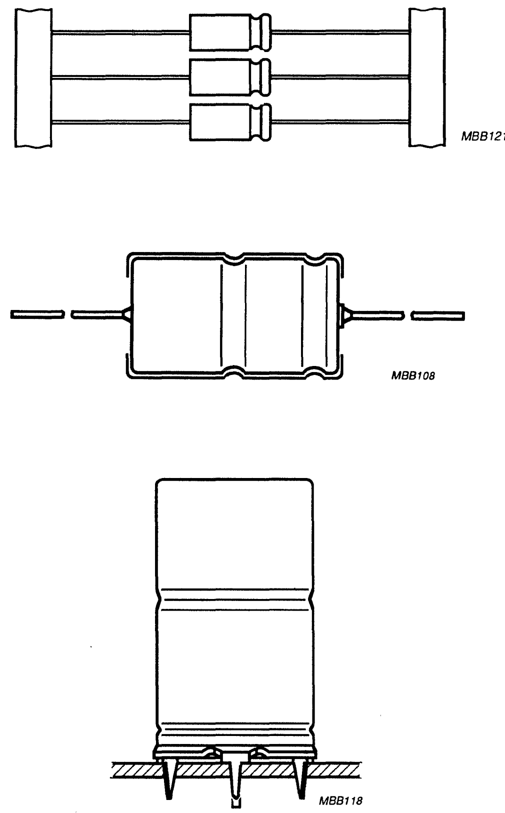


Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (∅ D_{nom} x L_{nom} in mm)	6.5 x 18 to 10 x 25	10 x 30 to 21 x 40
Rated capacitance range, C_R	1 to 220 µF	
Tolerance on C_R	–10 to +50%	
Rated voltage range, U_R	160 to 450 V	
Category temperature range	–40 to +85 °C	
Endurance test at 85 °C	2000 hours	5000 hours
Useful life at 85 °C	5000 hours	10 000 hours
Useful life at 40 °C, 1.4 I_R applied	120 000 hours	250 000 hours
Shelf life at 0 V, 85 °C	500 hours	500 hours
Basic specification	IEC 384-4/CECC 30 300, LL grade	
Detail specification	DIN 41240	
Climatic category IEC 68 DIN 40040	 40/085/56 GPF	

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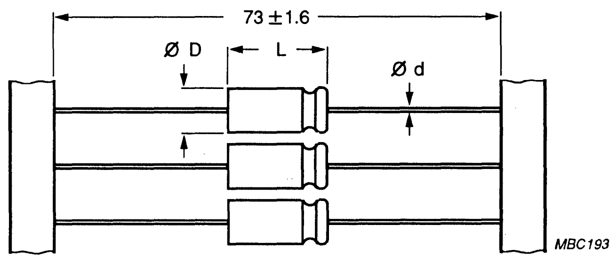
Table 1 Selection chart for C_RU_R and relevant nominal case sizes (∅ **D x L** in **mm**) * = preferred values

C_R (μF)		U_R (V)					
		160	**250**	**350**	**385**	**400**	**450**
1.0	*				6.5 x 18		
2.2	*		6.5 x 18		8 x 18		
4.7	*	6.5 x 18	8 x 18	10 x 18	10 x 25		
6.8				10 x 30	10 x 30	10 x 30	10 x 30
10	*	8 x 18	10 x 25 10 x 30	12.5 x 30	12.5 x 30	12.5 x 30	12.5 x 30
15			12.5 x 30	12.5 x 30	15 x 30	15 x 30	12.5 x 30
22	*	10 x 25 10 x 30	12.5 x 30	15 x 30	18 x 30	18 x 30	15 x 30
33		12.5 x 30	15 x 30	18 x 30	18 x 40	18 x 40	18 x 30
47	*	15 x 30	18 x 30	18 x 40	18 x 40	18 x 40	18 x 40
68		15 x 30	18 x 40	21 x 40	21 x 40	21 x 40	21 x 40
100	*	18 x 30	21 x 40				
150		18 x 40					
220	*	21 x 40					

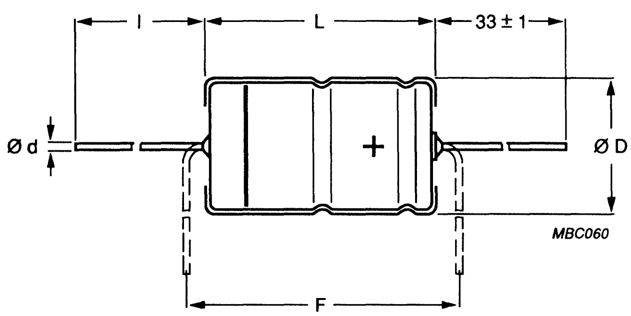
MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.
Tape dimensions are specified in chapter "PACKING".



Form BR: Taped on reel, case sizes 6.5 x 18 to 15 x 30.
Form BA: Taped in box (ammopack), case sizes 6.5 x 18 to 10 x 25.

Fig.2 Case sizes 6.5 x 18 to 15 x 30.

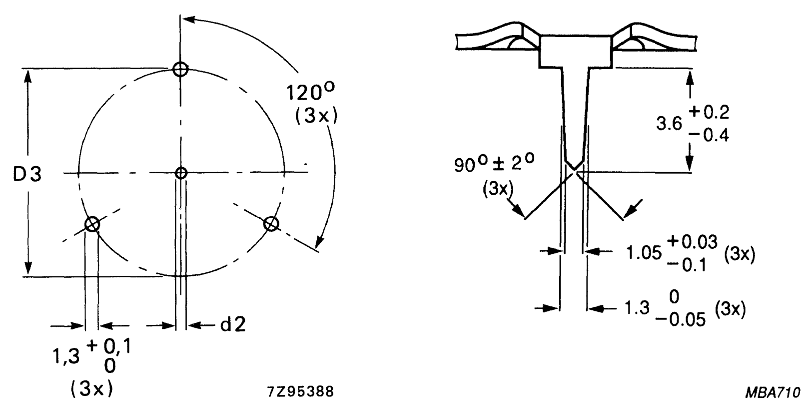


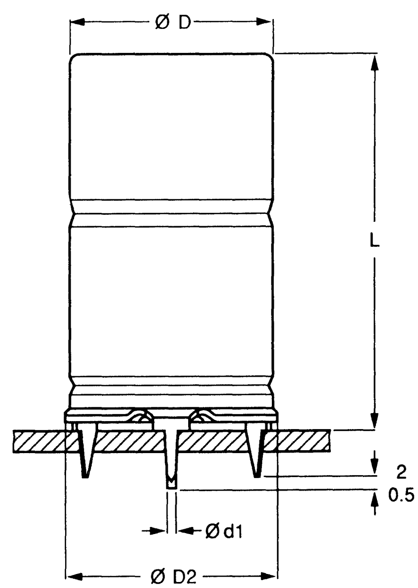
Form AA: Axial in box.
For case sizes 18 x 40 and 21 x 40, the stated L may be exceeded by 0.7 mm.

Fig.3 Case sizes 10 x 30 to 21 x 40.

Table 2 Axial, dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	AXIAL: Form AA, BA, and BR					APPROX. MASS	PACKING QUANTITIES		
		Ød	l	ØD_{max}	L_{max}	F_{min}		Form AA	Form BA	Form BR
6.5 x 18	4	0.8		6.9	18.5	25	1.3	–	1000	1000
8 x 18	5	0.8		8.5	18.5	25	1.7	–	500	500
10 x 18	6	0.8		10.5	18.5	25	2.5	–	500	500
10 x 25	7	0.8		10.5	25.0	30	3.3	–	500	500
10 x 30	00	0.8	55 ±1	10.5	30.5	35	4.8	200	–	500
12.5 x 30	01	0.8	55 ±1	13.0	30.5	35	7.4	200	–	400
15 x 30	02	0.8	55 ±1	15.5	30.5	35	11.7	200	–	250
18 x 30	03	0.8	55 ±1	18.5	30.5	35	12.9	200	–	–
18 x 40	04	0.8	34 ±1	18.5	41.5	45	19.4	100	–	–
21 x 40	05	0.8	34 ±1	21.5	41.5	45	24.7	100	–	–





Piercing diagram.

Form MR: case not insulated (insulation on request).
Especially for applications with severe shocks and vibrations.

Fig.4 Case sizes 15 x 30 to 21 x 40, single ended with mounting ring and pins.

Table 3 Single ended, dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	SINGLE ENDED WITH MOUNTING RING: Form MR						APPROX. MASS	PACKING QUANTITIES
		Ød_1	Ød_2	ØD_{max}	Ø$D2_{max}$	D3	L_{max}		
15 x 30	02	0.8	1.0 +0.1	15.5	17.5	16.5 ±0.2	33	11.7	200
18 x 30	03	0.8	1.0 +0.1	18.5	19.5	18.5 ±0.2	33	12.9	200
18 x 40	04	1.0	1.3 +0.1	18.5	19.5	18.5 ±0.2	45	19.4	100
21 x 40	05	1.0	1.3 +0.1	21.5	22.5	21.5 ±0.2	45	24.7	100

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 4 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz, tolerance −10 to +50%
I_R	= rated RMS ripple current at 100 Hz, 85 °C
I_{L1}	= max. leakage current after 1 minute at U_R
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	= max. impedance at 10 kHz.

Table 4 Electrical data

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
160	4.7	6.5 x 18	50	38	8	0.15	51	26
	10	8 x 18	70	68	14	0.15	24	12
	22	10 x 25	150	130	25	0.15	11	5.5
	22	10 x 30	110	42	25	0.10	7.2	4.5
	33	12.5 x 30	150	58	36	0.10	4.8	3.1
	47	15 x 30	190	78	49	0.10	3.4	2.1
	68	15 x 30	230	110	69	0.10	2.3	1.4
	100	18 x 30	310	150	100	0.10	1.6	1.0
	150	18 x 40	430	230	150	0.10	1.1	0.7
	220	21 x 40	570	330	220	0.10	0.7	0.5
250	2.2	6.5 x 18	35	28	6	0.10	72	50
	4.7	8 x 18	55	55	11	0.10	34	23
	10	10 x 25	90	95	19	0.10	16	11
	10	10 x 30	72	33	19	0.10	16	11
	15	12.5 x 30	100	44	27	0.10	11	7.4
	22	12.5 x 30	120	60	37	0.10	7.2	5.0
	33	15 x 30	160	84	54	0.10	4.8	3.4
	47	18 x 30	220	120	75	0.10	3.4	2.4
	68	18 x 40	290	160	110	0.10	2.3	1.7
	100	21 x 40	390	240	150	0.10	1.6	1.1

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 041/042/043 . . . . .

10 µF/250 V, −10/+50%

Case size 10 x 25; Form BR

Catalogue number: 2222 041 23109.

Table 5 Ordering information

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
160	4.7	6.5 x 18	4	–	041 21478	041 31478	–
	10	8 x 18	5	–	041 21109	041 31109	–
	22	10 x 25	7	–	041 21229	041 31229	–
	22	10 x 30	00	042 11229	042 21229	–	–
	33	12.5 x 30	01	042 11339	042 21339	–	–
	47	15 x 30	02	042 11479	042 21479	–	042 41479
	68	15 x 30	02	042 11689	042 21689	–	042 41689
	100	18 x 30	03	042 11101	–	–	042 41101
	150	18 x 40	04	043 11151	–	–	043 41151
	220	21 x 40	05	043 11221	–	–	043 41221
250	2.2	6.5 x 18	4	–	041 23228	041 33228	–
	4.7	8 x 18	5	–	041 23478	041 33478	–
	10	10 x 25	7	–	041 23109	041 33109	–
	10	10 x 30	00	042 13109	042 23109	–	–
	15	12.5 x 30	01	042 13159	042 23159	–	–
	22	12.5 x 30	01	042 13229	042 23229	–	–
	33	15 x 30	02	042 13339	042 23339	–	042 43339
	47	18 x 30	03	042 13479	–	–	042 43479
	68	18 x 40	04	043 13689	–	–	043 43689
	100	21 x 40	05	043 13101	–	–	043 43101

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
350	4.7	10 x 18	6	–	041 25478	041 35478	–
	6.8	10 x 30	00	042 15688	042 25688	–	–
	10	12.5 x 30	01	042 15109	042 25109	–	–
	15	12.5 x 30	01	042 15159	042 25159	–	–
	22	15 x 30	02	042 15229	042 25229	–	042 45229
	33	18 x 30	03	042 15339	–	–	042 45339
	47	18 x 40	04	043 15479	–	–	043 45479
	68	21 x 40	05	043 15689	–	–	043 45689
385	1	6.5 x 18	4	–	041 28108	041 38108	–
	2.2	8 x 18	5	–	041 28228	041 38228	–
	4.7	10 x 25	7	–	041 28478	041 38478	–
	6.8	10 x 30	00	042 18688	042 28688	–	–
	10	12.5 x 30	01	042 18109	042 28109	–	–
	15	15 x 30	02	042 18159	042 28159	–	042 48159
	22	18 x 30	03	042 18229	–	–	042 48229
	33	18 x 40	04	043 18339	–	–	043 48339
	47	18 x 40	04	043 18479	–	–	043 48479
	68	21 x 40	05	043 18689	–	–	043 48689
400	6.8	10 x 30	00	042 16688	042 26688	–	–
	10	12.5 x 30	01	042 16109	042 26109	–	–
	15	15 x 30	02	042 16159	042 26159	–	042 46159
	22	18 x 30	03	042 16229	–	–	042 46229
	33	18 x 40	04	043 16339	–	–	043 46339
	47	18 x 40	04	043 16479	–	–	043 46479
	68	21 x 40	05	043 16689	–	–	043 46689
450	6.8	10 x 30	00	042 17688	042 27688	–	–
	10	12.5 x 30	01	042 17109	042 27109	–	–
	15	12.5 x 30	01	042 17159	042 27159	–	–
	22	15 x 30	02	042 17229	042 27229	–	042 47229
	33	18 x 30	03	042 17339	–	–	042 47339
	47	18 x 40	04	043 17479	–	–	043 47479
	68	21 x 40	05	043 17689	–	–	043 47689

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
350	4.7	10 x 18	60	69	14	0.10	34	22
	6.8	10 x 30	60	32	18	0.10	23	14
	10	12.5 x 30	81	42	25	0.10	16	10
	15	12.5 x 30	100	57	36	0.10	11	6.7
	22	15 x 30	130	79	50	0.10	7.2	4.5
	33	18 x 30	160	110	73	0.10	4.8	3.1
	47	18 x 40	240	160	100	0.10	3.4	2.1
	68	21 x 40	320	220	150	0.10	2.3	1.4
385	1	6.5 x 18	20	19	4	0.10	160	100
	2.2	8 x 18	40	42	8	0.10	72	45
	4.7	10 x 25	70	71	15	0.10	34	22
	6.8	10 x 30	60	34	20	0.10	23	14
	10	12.5 x 30	81	45	27	0.10	16	10
	15	15 x 30	110	62	39	0.10	11	6.7
	22	18 x 30	150	86	55	0.10	7.2	4.5
	33	18 x 40	200	120	80	0.10	4.8	3.1
	47	18 x 40	240	170	110	0.10	3.4	2.1
	68	21 x 40	320	250	160	0.10	2.3	1.4
400	6.8	10 x 30	82	220	110	0.055	13	7.3
	10	12.5 x 30	130	240	110	0.055	8.8	4.6
	15	15 x 30	160	250	110	0.055	5.8	3.1
	22	18 x 30	210	280	120	0.055	4.0	2.1
	33	18 x 40	290	320	130	0.055	2.7	1.4
	47	18 x 40	330	370	140	0.055	1.9	1.1
	68	21 x 40	430	440	150	0.055	1.3	0.7
450	6.8	10 x 30	61	230	110	0.12	28	17
	10	12.5 x 30	83	240	110	0.12	19	12
	15	12.5 x 30	100	260	110	0.12	13	8
	22	15 x 30	140	290	120	0.12	8.7	5.4
	33	18 x 30	190	330	130	0.12	5.8	3.6
	47	18 x 40	250	390	140	0.12	4.1	2.5
	68	21 x 40	330	480	160	0.12	2.8	1.8

Marking

The capacitors are marked (where possible) with the following information:

- Rated capacitance in µF
- Tolerance on rated capacitance, code letter in accordance with IEC 62
- Rated voltage in V
- Group number (041, 042 or 043)
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Code indicating factory of origin
- Band to identify the negative terminal
- "+" - signs to identify the positive terminal.

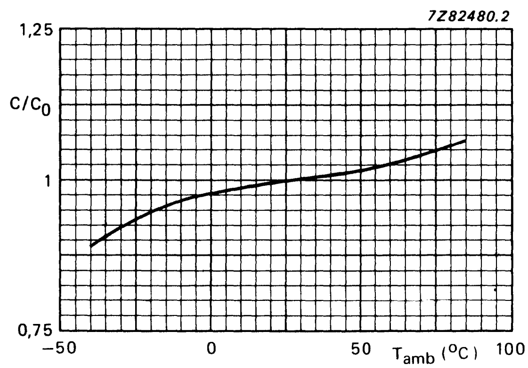
Voltage

Surge voltage for short periods	
160 and 250 V types	$U_s \leq 1.15 \times U_R$
350 to 450 V types	$U_s \leq 1.1 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	
case sizes 6.5 x 18 to 10 x 25	for CU ≤ 1000 µC: $I_{L1} \leq 0.05\ C_R \times U_R$ or 5 µA, whichever is greater for CU > 1000 µC: $I_{L1} \leq 0.03\ C_R \times U_R + 20$ µA
case sizes 10 x 30 to 21 x 40	160 to 385 V: $I_{L1} \leq 0.009\ C_R \times U_R + 10$ µA 400 and 450 V: $I_{L1} \leq 0.009\ C_R \times U_R + 200$ µA
After 5 minutes at U_R	
160 to 385 V	for CU ≤ 1000 µC: $I_{L5} \leq 0.01\ C_R \times U_R$ or 1 µA, whichever is greater for CU > 1000 µC: $I_{L5} \leq 0.006\ C_R \times U_R + 4$ µA
400 and 450 V	$I_{L5} \leq 0.002\ C_R \times U_R + 100$ µA

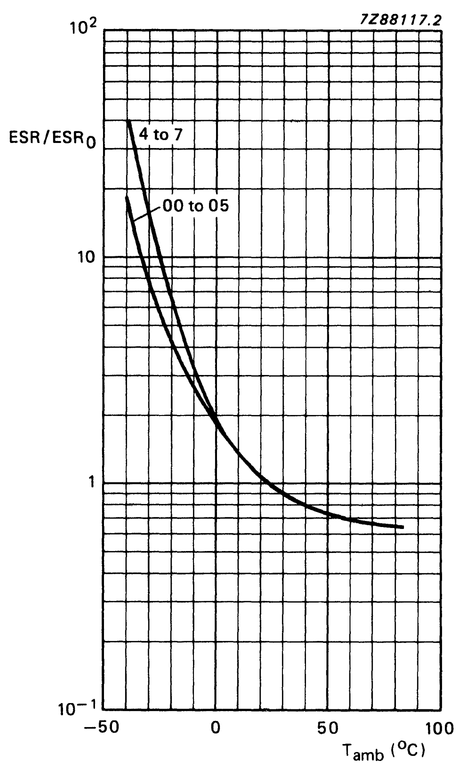
Capacitance (C)



C_0 = capacitance at 20 °C, 100 Hz.

Fig.5 Multiplier of capacitance (C/C_0) as a function of ambient temperature.

Equivalent series resistance (ESR)



4 to 7:

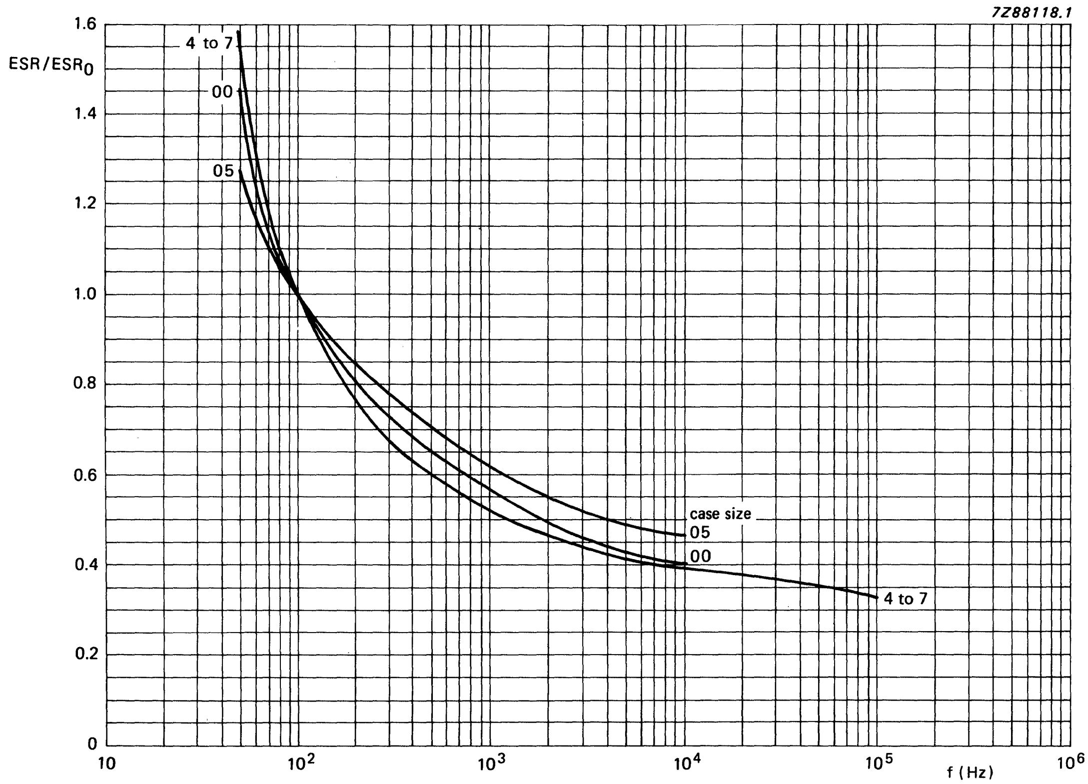
case sizes 6.5 x 18 to 10 x 25.

00 to 05:

case sizes 10 x 30 to 21 x 40.

ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.6 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature.



4 to 7:
case sizes 6.5 x 18 to 10 x 25.
00: case size 10 x 30.
05: case size 21 x 40.
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.7 Multiplier of ESR (ESR/ESR_0) as a function of frequency.

Equivalent series inductance (ESL)

Table 6 Equivalent series inductance, typical values

CASE SIZE (∅ x L) (mm)	AXIAL (nH)	SINGLE ENDED (nH)		CASE SIZE (∅ x L) (mm)	AXIAL (nH)	SINGLE ENDED (nH)
6.5 x 18	15	–		12.5 x 30	46	–
8 x 18	35	–		15 x 30	48	39
10 x 18	69	–		18 x 30	50	39
10 x 25	38	–		18 x 40	54	39
10 x 30	38	–		21 x 40	59	39

Impedance (Z)

4 to 7:
case sizes 6.5 x 18 to 10 x 25.
00 to 05:
case sizes 10 x 30 to 21 x 40.
Z_0 = impedance at 20 °C, 10 kHz.

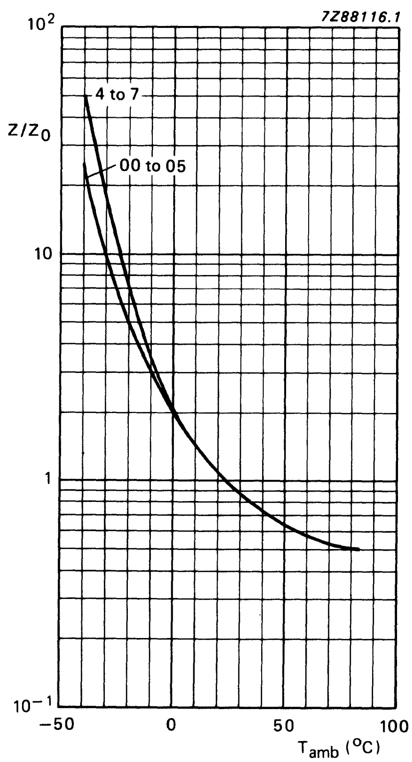
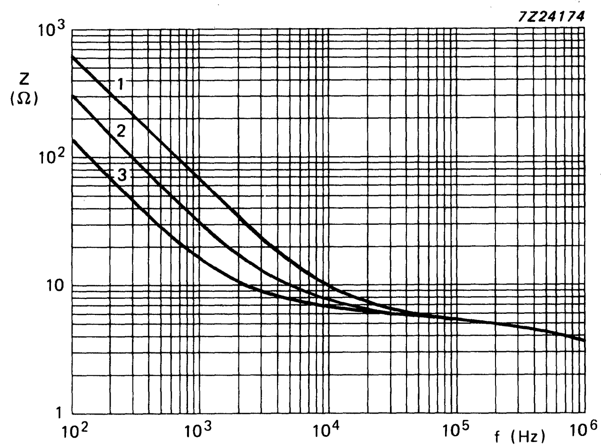
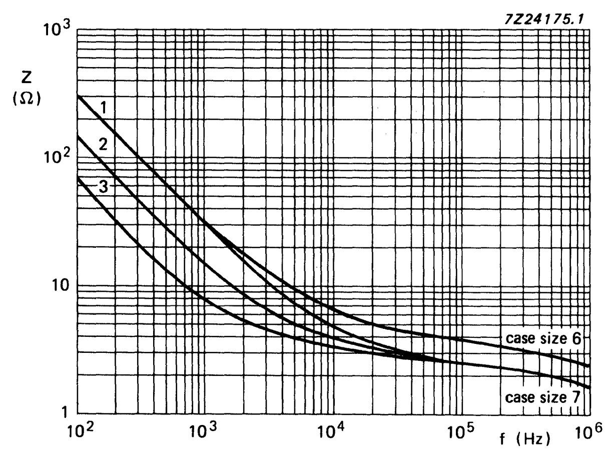


Fig.8 Multiplier of impedance (Z/Z_0) as a function of ambient temperature.



Curve 1: 2.2 μF
Curve 2: 4.7 μF
Curve 3: 10 μF.

Fig.9 Typical impedance as a function of frequency at 20 °C; case size 8 x 18.



Curve 1: 4.7 μF
Curve 2: 10 μF
Curve 3: 22 μF.

Fig.10 Typical impedance as a function of frequency at 20 °C;
case sizes 10 x 18 (case size 6) and 10 x 25 (case size 7).

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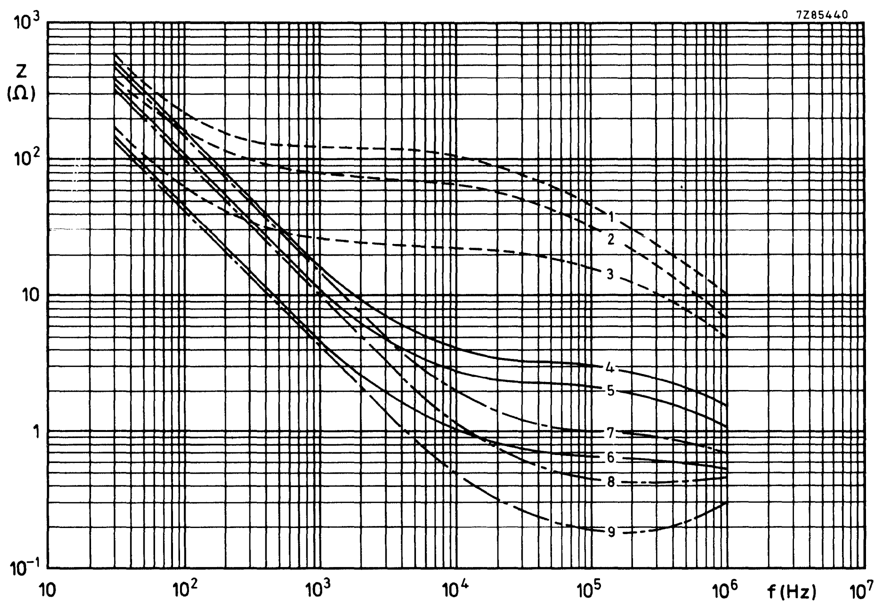


Curve 1: 10 µF - 350/385 V; –40 °C

Curve 2: 15 µF - 250 V; –40 °C

Curve 3: 33 µF - 160 V; –40 °C

Curve 4: 10 µF - 350/385 V; 20 °C

Curve 5: 15 µF - 250 V; 20 °C

Curve 6: 33 µF - 160 V; 20 °C

Curve 7: 10 µF - 350/385 V; 85 °C

Curve 8: 15 µF - 250 V; 85 °C

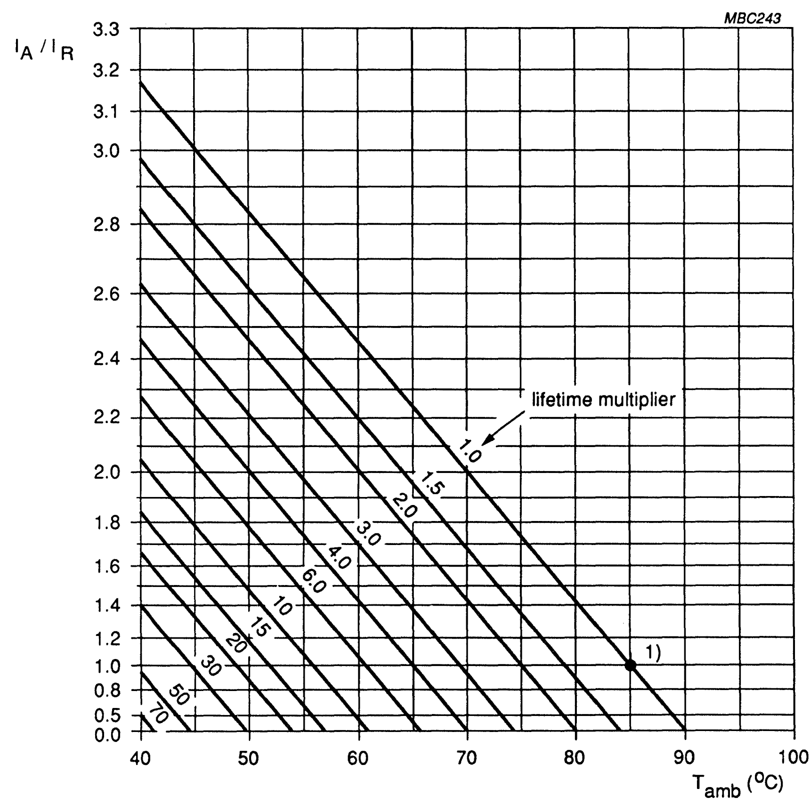
Curve 9: 33 µF - 160 V; 85 °C.

Fig.11 Typical impedance as a function of frequency at different temperatures; case size 12.5 x 30.

RIPPLE CURRENT and USEFUL LIFE

Table 7 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 85 °C, 100 Hz.

FREQUENCY (Hz)	I_R MULTIPLIER
50	0.75
100	1.0
300	1.15
1000	1.3
3000	1.4
≥10 000	1.5



I_A = actual ripple current at 100 Hz.
I_R = rated ripple current at 100 Hz, 85 °C.

1) Useful life at 85 °C and I_R applied.
case sizes 6.5 x 18 to 10 x 25: 5000 hours
case sizes 10 x 30 to 21 x 40: 10 000 hours.

Fig.12 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements".

Table 8

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 85 °C, U_R applied case sizes: 6.5 x 18 to 10 x 25: 2000 hours 10 x 30 to 21 x 40: 5000 hours	U_R 160 V: ΔC/C ±15% U_R 250 to 450 V: ΔC/C ±10% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied case sizes: 6.5 x 18 to 10 x 25: 5000 hours 10 x 30 to 21 x 40: 10 000 hours	U_R 160 V : ΔC/C ±45% U_R 250 to 450 V: ΔC/C ±30% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤1%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Axial leads, cylindrical aluminium case with safety vent, insulated with a blue sleeve
- Mounting ring version (single ended) not insulated
- Taped version up to 15 x 30 available for automatic insertion
- Charge and discharge proof
- Useful life: 5000 hours at 85 °C
- Highly miniaturized, extremely high CU-product per unit volume.

APPLICATIONS

- Audio-video, automotive and telecommunication
- Smoothing, filtering, buffering, timing
- Portable and mobile equipment (small size, low mass)
- Boards with restricted mounting height, vibration and shock resistant
- Equipment in compact design.

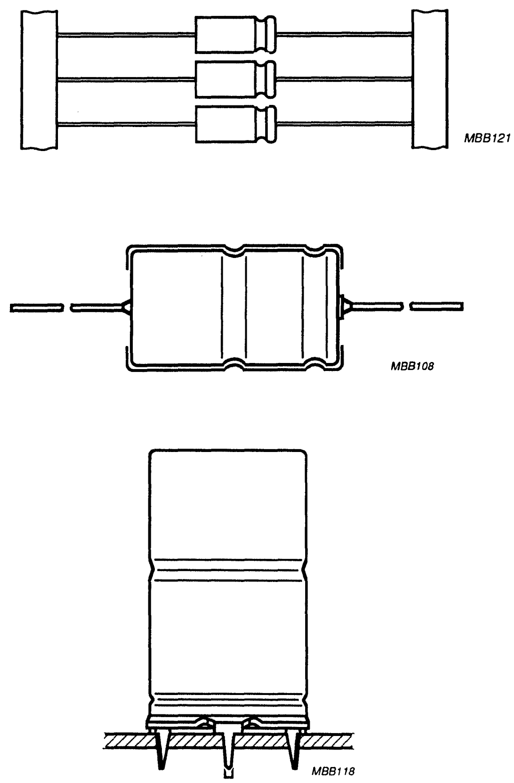


Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (∅ D_{nom} x L_{nom} in mm)	10 x 30 to 21 x 40
Rated capacitance range, C_R	330 to 22 000 µF
Tolerance on C_R	±20%
Rated voltage range, U_R	10 to 63 V
Category temperature range	–40 to +85 °C
Endurance test at 85 °C	2000 hours
Useful life at 85 °C	5000 hours
Useful life at 40 °C, 1.4 I_R applied	120 000 hours
Shelf life at 0 V, 85 °C	500 hours
Basic specification	IEC 384-4/CECC 30 300, LL grade
Detail specification	similar to DIN 41316 (with reduced dimensions)
Climatic category IEC 68 DIN 40040	 40/085/56 GPF

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Table 1 Selection chart for C_RU_R and relevant nominal case sizes (∅ **D x L** in **mm**)

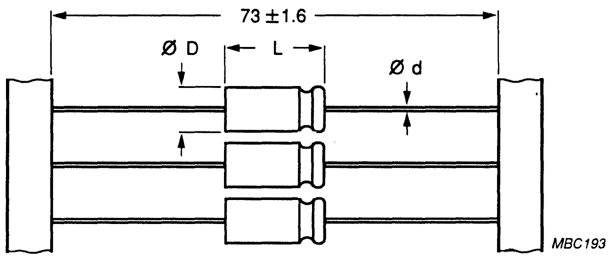
C_R (μF)	U_R (V)					
	10	**16**	**25**	**40**	**50**	**63**
330						10 x 30
470	for smaller CV - values see ASM 021 series				10 x 30	12.5 x 30
680				10 x 30	12.5 x 30	12.5 x 30
1000			10 x 30	12.5 x 30	12.5 x 30 [1]	15 x 30
1500		10 x 30	12.5 x 30	15 x 30	15 x 30 [1]	18 x 30
2200	10 x 30	12.5 x 30	12.5 x 30	15 x 30 [1]	18 x 30	18 x 40
3300	12.5 x 30	12.5 x 30	15 x 30	18 x 30 [1]	18 x 40	21 x 40
4700	12.5 x 30	15 x 30	18 x 30	18 x 40	21 x 40	
6800	15 x 30	18 x 30	18 x 40	21 x 40		
10 000	18 x 30	18 x 40	21 x 40			
15 000	18 x 40	21 x 40				
22 000	21 x 40					

Note

[1] Available to special order.

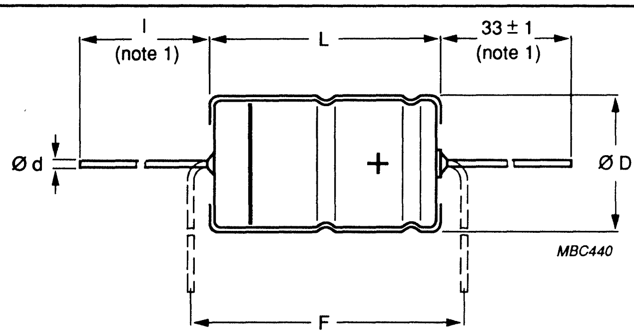
MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.
Tape dimensions are specified in chapter "PACKING",



Form BR: Taped on reel.

Fig.2 Case sizes 10 x 30 to 15 x 30.

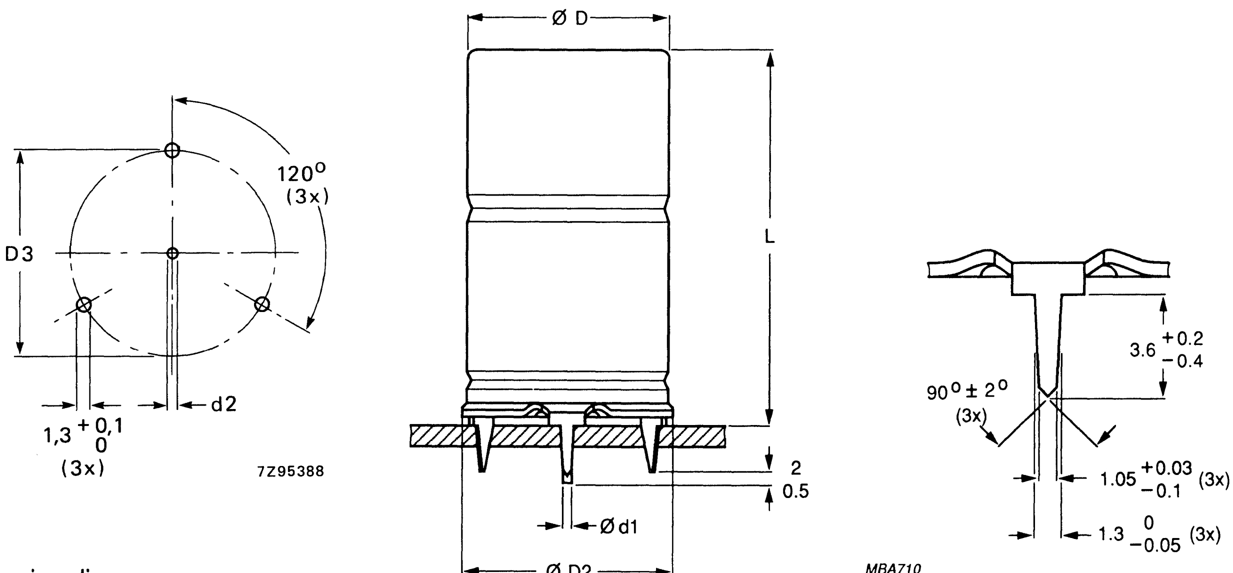


Form AA: Axial in box.
For case sizes 18 x 40 and 21 x 40, the stated L may be exceeded by 0.7 mm.

Fig.3 Case sizes 10 x 30 to 21 x 40.

Table 2 **Axial**, dimensions in mm; mass in g

CASE SIZE $\varnothing D_{nom} \times L_{nom}$	CASE CODE	AXIAL: Form AA and BR					APPROX. MASS	PACKING QUANTITIES	
		Ød	l	$\varnothing D_{max}$	L_{max}	F_{min}		Form AA	Form BR
10 x 30	00	0.8	55 ±1	10.5	30.5	35	4.8	200	500
12.5 x 30	01	0.8	55 ±1	13.0	30.5	35	7.4	200	400
15 x 30	02	0.8	55 ±1	15.5	30.5	35	11.7	200	250
18 x 30	03	0.8	55 ±1	18.5	30.5	35	12.9	200	–
18 x 40	04	0.8	34 ±1	18.5	41.5	45	19.4	100	–
21 x 40	05	0.8	34 ±1	21.5	41.5	45	24.7	100	–



Piercing diagram.

Form MR: case not insulated (insulation on request).

Especially for applications with severe shocks and vibrations.

Fig.4 Case sizes 15 x 30 to 21 x 40, single ended with mounting ring and pins.

Table 3 **Single ended,** dimensions in mm; mass in g

CASE SIZE $\varnothing D_{nom} \times L_{nom}$	CASE CODE	SINGLE ENDED WITH MOUNTING RING: Form MR						APPROX. MASS	PACKING QUANTITIES
		$\varnothing d_1$	$\varnothing d_2$	$\varnothing D_{max}$	$\varnothing D2_{max}$	D3	L_{max}		
15 x 30	02	0.8	1.0 +0.1	15.5	17.5	16.5 ±0.2	33	11.7	200
18 x 30	03	0.8	1.0 +0.1	18.5	19.5	18.5 ±0.2	33	12.9	200
18 x 40	04	1.0	1.3 +0.1	18.5	19.5	18.5 ±0.2	45	19.4	100
21 x 40	05	1.0	1.3 +0.1	21.5	22.5	21.5 ±0.2	45	24.7	100

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 4 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz, tolerance ±20%
I_R	= rated RMS ripple current at 100 Hz, 85 °C
I_{L1}	= max. leakage current after 1 minute at U_R
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= max. equivalent series resistance at 100 Hz
Z	= max. impedance at 10 kHz

Table 4 Electrical data

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)
10	2200	10 x 30	595	136	48	0.31	225	150
	3300	12.5 x 30	920	202	70	0.28	155	105
	4700	12.5 x 30	900	286	98	0.50	184	155
	6800	15 x 30	1120	412	140	0.43	100	75
	10 000	18 x 30	1370	604	204	0.51	81	56
	15 000	18 x 40	1770	904	304	0.59	63	44
	22 000	21 x 40	2160	1320	444	0.69	50	38
16	1500	10 x 30	580	148	52	0.22	238	150
	2200	12.5 x 30	880	215	74	0.20	145	105
	3300	12.5 x 30	850	321	110	0.36	189	155
	4700	15 x 30	1120	455	153	0.30	100	69
	6800	18 x 30	1430	657	222	0.32	75	56
	10 000	18 x 40	1770	964	323	0.39	63	44
	15 000	21 x 40	2160	1440	484	0.47	50	38
25	1000	10 x 30	540	154	54	0.17	275	150
	1500	12.5 x 30	780	229	79	0.16	170	105
	2200	12.5 x 30	750	334	114	0.25	203	155
	3300	15 x 30	1080	499	169	0.22	106	69
	4700	18 x 30	1370	709	239	0.24	81	56
	6800	18 x 40	1690	1020	344	0.29	69	44
	10 000	21 x 40	1840	1500	504	0.43	69	38

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ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 049 . . . . .
4700 μF/16 V, ±20%
Case size 15 x 30; Form BR
Catalogue number: 2222 049 25472.

Table 5 Ordering information

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222		
				AXIAL		SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	MOUNTING RING Form MR
10	2200	10 x 30	00	049 14222	049 24222	–
	3300	12.5 x 30	01	049 14332	049 24332	–
	4700	12.5 x 30	01	049 14472	049 24472	–
	6800	15 x 30	02	049 14682	049 24682	049 44682
	10 000	18 x 30	03	049 14103	–	049 44103
	15 000	18 x 40	04	049 14153	–	049 44153
	22 000	21 x 40	05	049 14223	–	049 44223
16	1500	10 x 30	00	049 15152	049 25152	–
	2200	12.5 x 30	01	049 15222	049 25222	–
	3300	12.5 x 30	01	049 15332	049 25332	–
	4700	15 x 30	02	049 15472	049 25472	049 45472
	6800	18 x 30	03	049 15682	–	049 45682
	10 000	18 x 40	04	049 15103	–	049 45103
	15 000	21 x 40	05	049 15153	–	049 45153
25	1000	10 x 30	00	049 16102	049 26102	–
	1500	12.5 x 30	01	049 16152	049 26152	–
	2200	12.5 x 30	01	049 16222	049 26222	–
	3300	15 x 30	02	049 16332	049 26332	049 46332
	4700	18 x 30	03	049 16472	–	049 46472
	6800	18 x 40	04	049 16682	–	049 46682
	10 000	21 x 40	05	049 16103	–	049 46103

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (mΩ)	Z 10 kHz (mΩ)
40	680	10 x 30	450	167	59	0.17	400	263
	1000	12.5 x 30	730	244	84	0.14	220	150
	1500	15 x 30	960	364	124	0.14	140	90
	2200 [1)]	15 x 30	920	532	180	0.22	175	119
	3300 [1)]	18 x 30	1100	796	268	0.24	125	94
	4700	18 x 40	1360	1130	380	0.29	106	75
	6800	21 x 40	1690	1640	548	0.43	81	63
50	470	10 x 30	480	145	51	0.10	345	178
	680	12.5 x 30	620	208	72	0.11	264	146
	1000 [1)]	12.5 x 30	600	304	104	0.23	390	325
	1500 [1)]	15 x 30	695	454	154	0.23	265	220
	2200	18 x 30	925	664	224	0.24	185	160
	3300	18 x 40	1270	994	334	0.24	125	110
	4700	21 x 40	1560	1410	474	0.26	98	85
63	330	10 x 30	440	129	46	0.09	419	250
	470	12.5 x 30	610	182	63	0.09	280	165
	680	12.5 x 30	550	261	90	0.19	475	400
	1000	15 x 30	815	382	130	0.12	188	119
	1500	18 x 30	1050	571	193	0.13	139	94
	2200	18 x 40	1360	836	280	0.15	106	75
	3300	21 x 40	1690	1250	420	0.17	81	56

Note

[1)] Available to special order.

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222		
				AXIAL		SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	MOUNTING RING Form MR
40	680	10 x 30	00	049 17681	049 27681	–
	1000	12.5 x 30	01	049 17102	049 27102	–
	1500	15 x 30	02	049 17152	049 27152	049 47152
	2200 1)	15 x 30	02	049 17222	049 27222	049 47222
	3300 1)	18 x 30	03	049 17332	–	049 47332
	4700	18 x 40	04	049 17472	–	049 47472
	6800	21 x 40	05	049 17682	–	049 47682
50	470	10 x 30	00	049 11471	049 21471	–
	680	12.5 x 30	01	049 11681	049 21681	–
	1000 1)	12.5 x 30	01	049 11102	049 21102	–
	1500 1)	15 x 30	02	049 11152	049 21152	049 41152
	2200	18 x 30	03	049 11222	–	049 41222
	3300	18 x 40	04	049 11332	–	049 41332
	4700	21 x 40	05	049 11472	–	049 41472
63	330	10 x 30	00	049 18331	049 28331	–
	470	12.5 x 30	01	049 18471	049 28471	–
	680	12.5 x 30	01	049 18681	049 28681	–
	1000	15 x 30	02	049 18102	049 28102	049 48102
	1500	18 x 30	03	049 18152	–	049 48152
	2200	18 x 40	04	049 18222	–	049 48222
	3300	21 x 40	05	049 18332	–	049 48332

Note

1) Available to special order.

Marking

The capacitors are marked (where possible) with the following information:

- Rated capacitance in µF
- Tolerance on rated capacitance
- Rated voltage in V
- Group number (049)
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Code indicating factory of origin
- Band to identify the negative terminal
- "+" - signs to identify the positive terminal.

Voltage

Surge voltage for short periods	$U_s \leq 1.15 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$

Equivalent series inductance (ESL)

Table 6 Equivalent series inductance, typical values

CASE SIZE (∅ x L) (mm)	AXIAL (nH)	SINGLE ENDED (nH)
10 x 30	38	–
12.5 x 30	46	–
15 x 30	48	39
18 x 30	50	39
18 x 40	54	39
21 x 40	59	39

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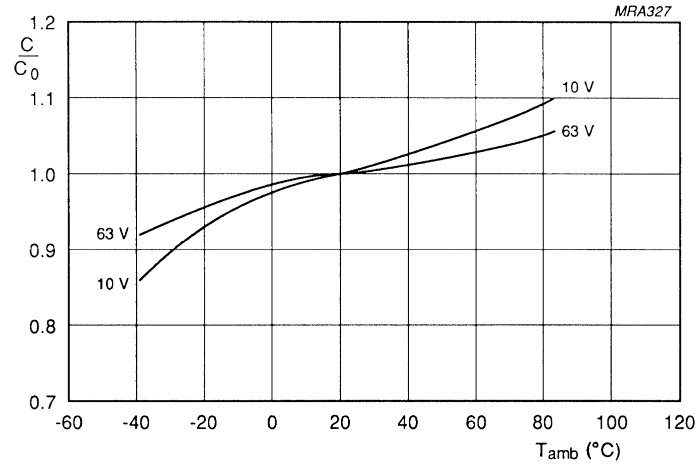
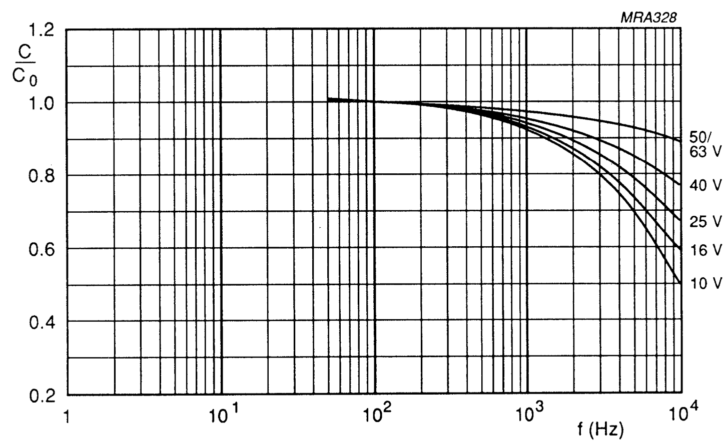
Capacitance (C)



C_0 = capacitance at 20 °C, 100 Hz.

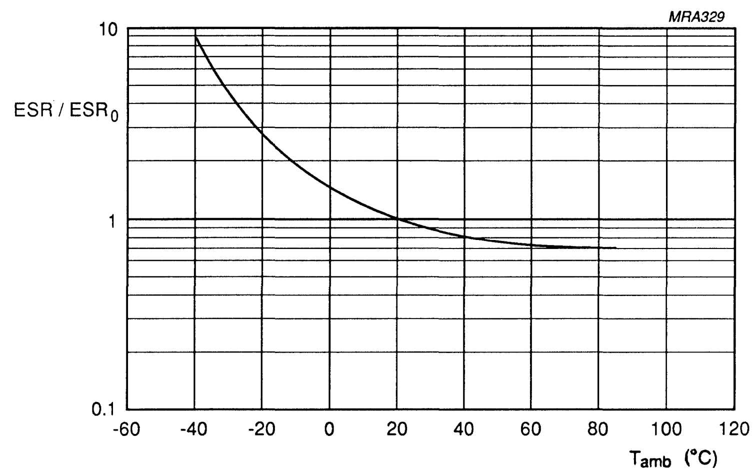
Fig.5 Multiplier of capacitance (C/C_0) as a function of ambient temperature.



C_0 = capacitance at 20 °C, 100 Hz.

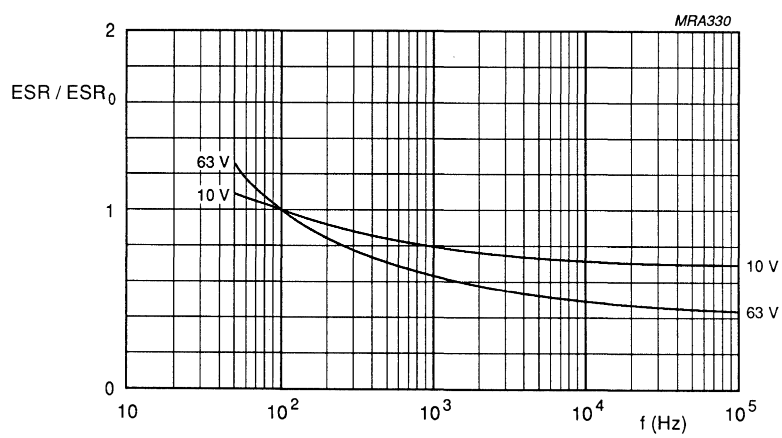
Fig.6 Multiplier of capacitance (C/C_0) as a function of frequency.

Equivalent series resistance (ESR)



ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature.



ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.8 Multiplier of ESR (ESR/ESR_0) as a function of frequency.

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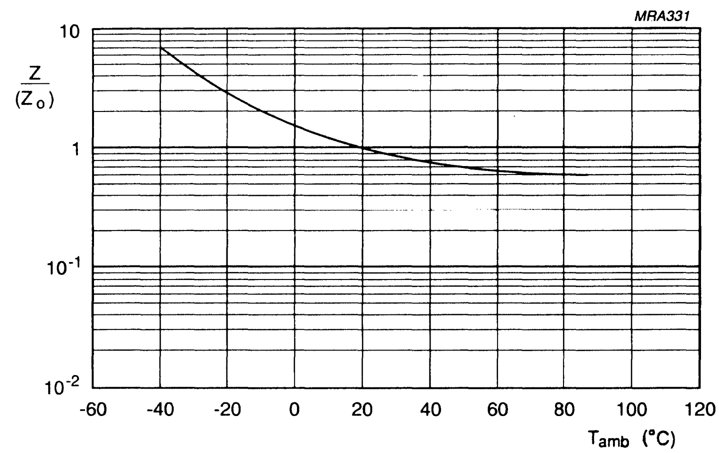
Impedance (Z)



Z_0 = impedance at 20 °C, 10 kHz.

Fig.9 Multiplier of impedance (Z/Z_0) as a function of ambient temperature.

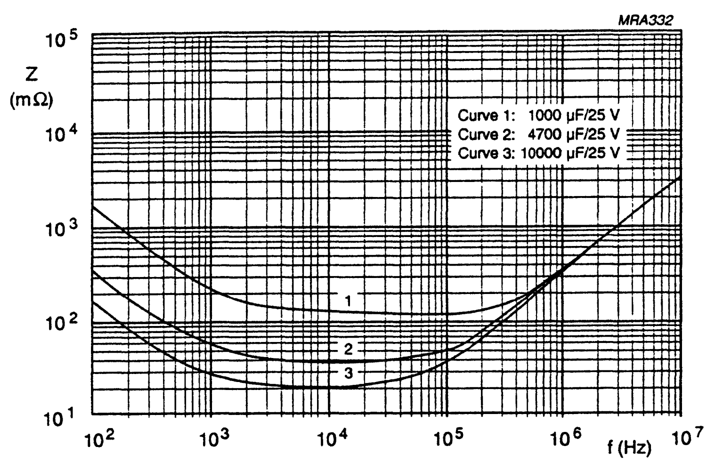


Fig.10 Typical impedance as a function of frequency at 20 °C.

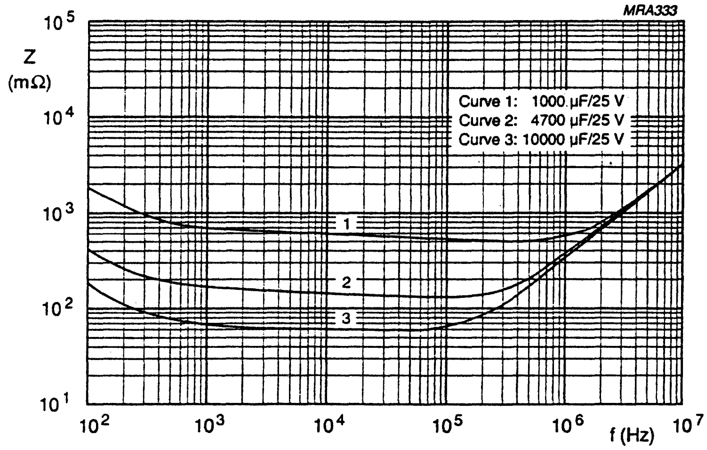


Fig.11 Typical impedance as a function of frequency at –25 °C.

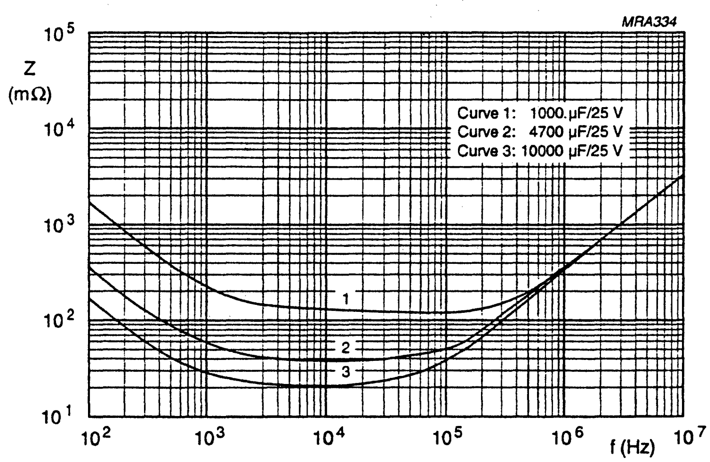
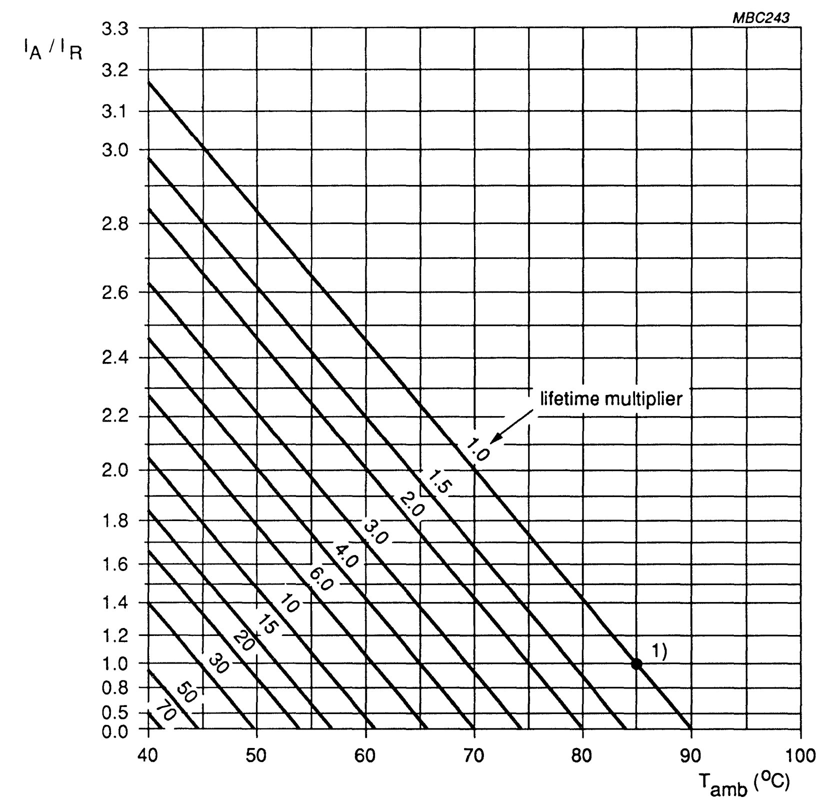


Fig.12 Typical impedance as a function of frequency at –40 °C.

RIPPLE CURRENT and USEFUL LIFE

Table 7 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 85 °C, 100 Hz.

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 10 and 16 V	U_R = 25 and 40 V	U_R = 50 and 63 V
50	0.95	0.9	0.85
100	1.0	1.0	1.0
300	1.07	1.12	1.2
1000	1.12	1.2	1.3
3000	1.15	1.25	1.35
≥10 000	1.2	1.3	1.4



I_A = actual ripple current at 100 Hz.

I_R = rated ripple current at 100 Hz, 85 °C.

1) Useful life at 85 °C and I_R applied: 5000 hours.

Fig.13 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 8

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	Reference		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 85 °C, U_R applied 2000 hours	ΔC/C ±15% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied 5000 hours	ΔC/C ±45% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤1%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Axial leads, cylindrical aluminium case, insulated with a blue sleeve
- Mounting ring version (single ended) not insulated
- Case sizes 10 x 30 to 21 x 40 with safety vent
- Taped versions up to 15 x 30 available for automatic insertion
- Charge and discharge proof
- Extra long useful life: 4000 hours at 125 °C, high reliability
- Extended temperature range: 125 °C (usable up to 150 °C)
- Miniaturized, high CU-product per unit volume.

APPLICATIONS

- Automotive, industrial and telecommunication
- Smoothing, filtering, coupling, decoupling, timing
- For use after very long storage (10 years) without voltage applied
- Portable and mobile equipment (small size, low mass)
- Low mounting height boards, vibration and shock resistant
- Outdoor applications, e.g. aerial amplifiers.

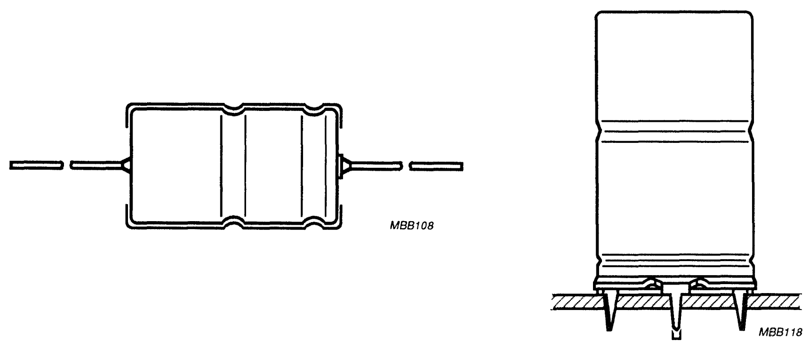


Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (Ø D_{nom} x L_{nom} in mm)	6.5 x 18 to 10 x 25	10 x 30 to 21 x 40
Rated capacitance range, C_R	1 to 15 000 µF	
Tolerance on C_R	±20%	
Rated voltage range, U_R	6.3 to 200 V	
Category temperature range	–40 to +125 °C	–55 to +125 °C
Endurance test at 150 °C	500 hours	1000 hours
Endurance test at 125 °C	2000 hours	3000 hours
Useful life at 125 °C	4000 hours	4000 hours
Useful life at 40 °C, 1.8 I_R applied	500 000 hours	500 000 hours
Shelf life at 0 V, 125 °C 6.3 to 63 V types 100 and 200 V types	 500 hours 100 hours	
Basic specification	IEC 384-4/CECC 30 300, LL grade	
Detail specification	similar to DIN 41257 (with reduced dimensions)	
Climatic category IEC 68 DIN 40040	 40/125/56 GKD	 55/125/56 FKD

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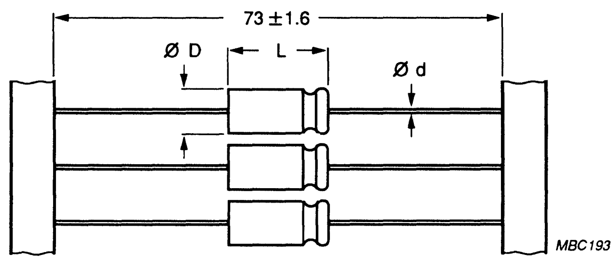
Table 1 Selection chart for C_RU_R and relevant nominal case sizes (∅ **D x L** in **mm**) * = preferred values

C_R (µF)	U_R (V)							
	6.3	**10**	**16**	**25**	**40**	**63**	**100**	**200**
1.0						6.5 x 18*		
2.2						6.5 x 18*		6.5 x 18*
4.7						6.5 x 18*	6.5 x 18*	8 x 18*
10						6.5 x 18*	6.5 x 18*	10 x 25*
15						6.5 x 18	8 x 18	10 x 30
22						6.5 x 18*	8 x 18*	12 5 x 30*
33						8 x 18	10 x 25	15 x 30
47					6.5 x 18*	8 x 18*	10 x 25* 10 x 30*	18 x 30*
68					8 x 18	10 x 18	12.5 x 30	18 x 40
100				6.5 x 18*	8 x 18*	10 x 25* 10 x 30*	12.5 x 30*	21 x 40*
150			6.5 x 18	8 x 18	10 x 18	12.5 x 30	15 x 30	
220		6.5 x 18*	8 x 18*	10 x 18*	10 x 25* 10 x 30*	12.5 x 30*	18 x 30*	
330	6.5 x 18*	8 x 18*	10 x 18*	10 x 25*	12.5 x 30*	15 x 30*	18 x 40*	
470		8 x 18*	10 x 18*	10 x 25* 10 x 30*	12.5 x 30*	18 x 30*	21 x 40*	
680		10 x 18*	10 x 25* 10 x 30*	12.5 x 30*	15 x 30*	18 x 40*		
1000	10 x 18*	10 x 25* 10 x 30*	12.5 x 30*	12.5 x 30*	18 x 30*	21 x 40*		
1500	10 x 25* 10 x 30*	12.5 x 30*	12.5 x 30*	15 x 30*	18 x 40*			
2200	12.5 x 30*	12.5 x 30*	15 x 30*	18 x 30*	21 x 40*			
3300	12.5 x 30*	15 x 30 *	18 x 30*	18 x 40*				
4700	15 x 30*	18 x 30*	18 x 40*	21 x 40*				
6800	18 x 30*	18 x 40*	21 x 40*					
10 000	18 x 40*	21 x 40*						
15 000	21 x 40*							

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

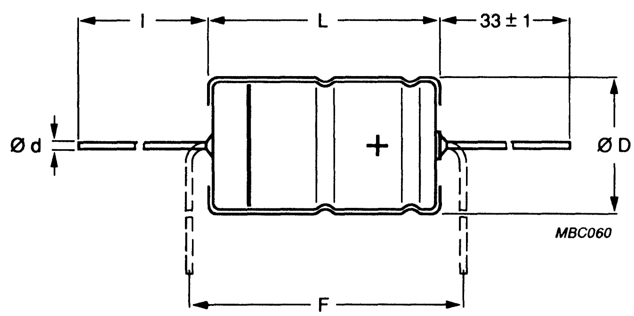
Dimensions in mm.
Tape dimensions are specified in chapter "PACKING",



Form BR: Taped on reel, case sizes 6.5 x 18 to 15 x 30.

Form BA: Taped in box (ammopack), case sizes 6.5 x 18 to 10 x 25.

Fig.2 Case sizes 6.5 x 18 to 15 x 30.



Form AA: Axial in box.

Fig.3 Case sizes 10 x 30 to 21 x 40.

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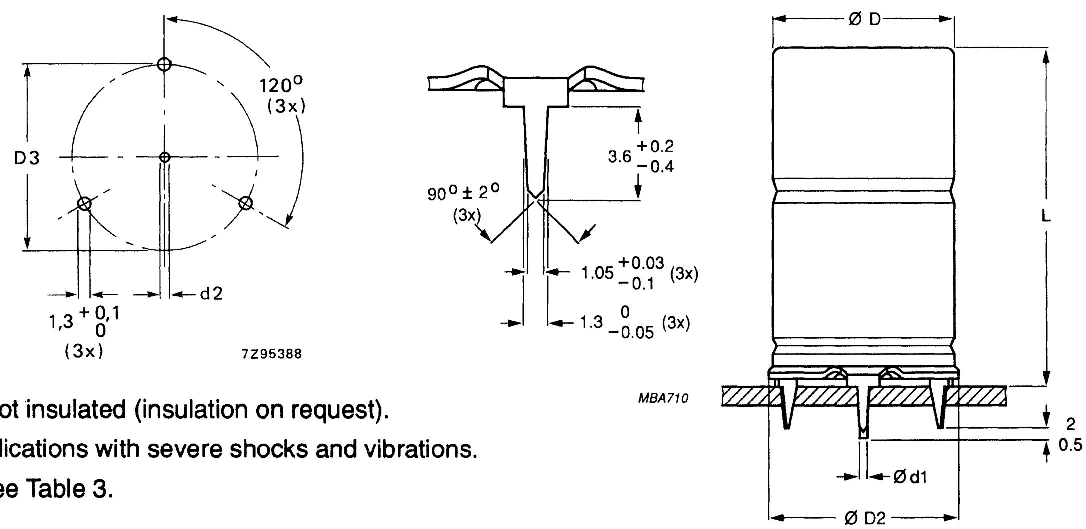
Table 2 Axial, dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	AXIAL: Form AA, BA, and BR					APPROX. MASS	PACKING QUANTITIES		
		Ød	l	ØD_{max}	L_{max}	F_{min}		Form AA	Form BA	Form BR
6.5 x 18	4	0.8		6.9	18.5	25	1.3	–	1000	1000
8 x 18	5	0.8		8.5	18.5	25	1.7	–	500	500
10 x 18	6	0.8		10.5	18.5	25	2.5	–	500	500
10 x 25	7	0.8		10.5	25.0	30	3.3	–	500	500
10 x 30	00	0.8	55 ±1	10.5	30.5	35	4.8	200	–	500
12.5 x 30	01	0.8	55 ±1	13.0	30.5	35	7.4	200	–	400
15 x 30	02	0.8	55 ±1	15.5	30.5	35	11.7	200	–	250
18 x 30	03	0.8	55 ±1	18.5	30.5	35	12.9	200	–	–
18 x 40 (note 1)	04	0.8	34 ±1	18.5	41.5	45	19.4	100	–	–
21 x 40 (note 1)	05	0.8	34 ±1	21.5	41.5	45	24.7	100	–	–

Note

1. For case sizes 18 x 40 and 21 x 40, the stated L_{max} may be exceeded by 0.7 mm.



Piercing diagram.

Form MR: case not insulated (insulation on request).
Especially for applications with severe shocks and vibrations.
For dimensions see Table 3.

Fig.4 Case sizes 15 x 30 to 21 x 40, single ended with mounting ring and pins.

Table 3 Single ended, dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	SINGLE ENDED WITH MOUNTING RING: Form MR						APPROX. MASS	PACKING QUANTITIES
		Ød_1	Ød_2	ØD_{max}	ØD2$_{max}$	D3	L_{max}		
15 x 30	02	0.8	1.0 +0.1	15.5	17.5	16.5 ±0.2	33	8.6	200
18 x 30	03	0.8	1.0 +0.1	18.5	19.5	18.5 ±0.2	33	11.5	200
18 x 40	04	1.0	1.3 +0.1	18.5	19.5	18.5 ±0.2	45	14.5	100
21 x 40	05	1.0	1.3 +0.1	21.5	22.5	21.5 ±0.2	45	19.7	100

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 4 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz, tolerance ±20%
I_R	= rated RMS ripple current at 100 Hz, 125 °C
I_{L1}	= max. leakage current after 1 minute at U_R
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	= max. impedance at 10 kHz

Table 4 Electrical data

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 125 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
6.3	330	6.5 x 18	112	20	8.2	0.50	2.41	2.1
	1000	10 x 18	251	42	17	0.50	0.79	0.8
	1500	10 x 25	352	61	23	0.50	0.53	0.53
	1500	10 x 30	416	61	23	0.46	0.485	0.45
	2200	12.5 x 30	590	87	32	0.46	0.305	0.28
	3300	12.5 x 30	648	129	46	0.58	0.280	0.27
	4700	15 x 30	826	182	63	0.58	0.185	0.18
	6800	18 x 30	1040	261	90	0.66	0.155	0.15
	10 000	18 x 40	1417	382	130	0.66	0.098	0.10
	15 000	21 x 40	1707	571	193	0.77	0.082	0.10
10	220	6.5 x 18	109	20	8.4	0.35	2.53	2.1
	330	8 x 18	150	24	11	0.35	1.69	1.4
	470	8 x 18	179	32	13	0.35	1.19	1.0
	680	10 x 18	247	45	18	0.35	0.82	0.81
	1000	10 x 25	343	64	24	0.35	0.56	0.55
	1000	10 x 30	409	64	24	0.32	0.505	0.45
	1500	12.5 x 30	590	94	34	0.32	0.285	0.28
	2200	12.5 x 30	634	136	48	0.40	0.290	0.27
	3300	15 x 30	826	202	70	0.40	0.190	0.18
	4700	18 x 30	1035	286	98	0.46	0.155	0.15
	6800	18 x 40	1395	412	140	0.53	0.100	0.10
	10 000	21 x 40	1674	604	200	0.53	0.084	0.10

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 118 . . . . .
1000 µF/10 V, ±20%
Case size 10 x 30; Form BR
Catalogue number: 2222 118 24102.

Table 5 Ordering Information

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
6.3	330	6.5 x 18	4	–	118 23331	118 33331	–
	1000	10 x 18	6	–	118 23102	118 33102	–
	1500	10 x 25	7	–	118 90502	118 90503	–
	1500	10 x 30	00	118 13152	118 23152	–	–
	2200	12.5 x 30	01	118 13222	118 23222	–	–
	3300	12.5 x 30	01	118 13332	118 23332	–	–
	4700	15 x 30	02	118 13472	118 23472	–	118 43472
	6800	18 x 30	03	118 13682	–	–	118 43682
	10 000	18 x 40	04	118 13103	–	–	118 43103
	15 000	21 x 40	05	118 13153	–	–	118 43153
10	220	6.5 x 18	4	–	118 24221	118 34221	–
	330	8 x 18	5	–	118 24331	118 34331	–
	470	8 x 18	5	–	118 24471	118 34471	–
	680	10 x 18	6	–	118 24681	118 34681	–
	1000	10 x 25	7	–	118 90504	118 90505	–
	1000	10 x 30	00	118 14102	118 24102	–	–
	1500	12.5 x 30	01	118 14152	118 24152	–	–
	2200	12.5 x 30	01	118 14222	118 24222	–	–
	3300	15 x 30	02	118 14332	118 24332	–	118 44332
	4700	18 x 30	03	118 14472	–	–	118 44472
	6800	18 x 40	04	118 14682	–	–	118 44682
	10 000	21 x 40	05	118 14103	–	–	118 44103

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 125 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
16	150	6.5 x 18	106	20	8.8	0.25	2.65	2.2
	220	8 x 18	145	25	11	0.25	1.81	1.5
	330	10 x 18	204	36	15	0.25	1.21	1.2
	470	10 x 18	243	49	19	0.25	0.85	0.83
	680	10 x 25	335	69	30	0.25	0.58	0.57
	680	10 x 30	389	69	30	0.22	0.525	0.45
	1000	12.5 x 30	557	100	36	0.22	0.345	0.28
	1500	12.5 x 30	609	148	52	0.29	0.305	0.27
	2200	15 x 30	790	215	74	0.29	0.205	0.18
	3300	18 x 30	1008	321	110	0.34	0.165	0.15
	4700	18 x 40	1363	455	150	0.34	0.105	0.10
	6800	21 x 40	1627	657	220	0.38	0.088	0.10
25	100	6.5 x 18	102	20	9	0.18	2.86	2.3
	150	8 x 18	141	27	12	0.18	1.91	1.55
	220	10 x 18	196	37	15	0.18	1.30	1.25
	330	10 x 25	274	54	21	0.18	0.87	0.82
	470	10 x 25	327	75	28	0.18	0.61	0.57
	470	10 x 30	366	75	28	0.18	0.61	0.50
	680	12.5 x 30	515	106	38	0.18	0.42	0.30
	1000	12.5 x 30	531	154	54	0.24	0.375	0.28
	1500	15 x 30	691	229	79	0.25	0.263	0.22
	2200	18 x 30	919	334	110	0.26	0.185	0.17
	3300	18 x 40	1280	499	170	0.26	0.12	0.11
	4700	21 x 40	1464	709	240	0.28	0.095	0.10
40	47	6.5 x 18	89.8	20	7.8	0.11	3.72	2.8
	68	8 x 18	121	20	9.4	0.11	2.57	1.9
	100	8 x 18	147	28	12	0.11	1.75	1.3
	150	10 x 18	207	40	16	0.11	1.17	1.0
	220	10 x 25	287	57	22	0.11	0.80	0.68
	220	10 x 30	338	57	22	0.10	0.70	0.55
	330	12.5 x 30	484	83	30	0.10	0.43	0.33
	470	12.5 x 30	522	117	42	0.11	0.38	0.30
	680	15 x 30	695	167	58	0.11	0.255	0.23
	1000	18 x 30	852	244	84	0.13	0.205	0.18
	1500	18 x 40	1196	364	120	0.13	0.13	0.11
	2200	21 x 40	1403	532	180	0.15	0.105	0.10

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
16	150	6.5 x 18	4	–	118 25151	118 35151	–
	220	8 x 18	5	–	118 25221	118 35221	–
	330	10 x 18	6	–	118 25331	118 35331	–
	470	10 x 18	6	–	118 25471	118 35471	–
	680	10 x 25	7	–	118 90506	118 90507	–
	680	10 x 30	00	118 15681	118 25681	–	–
	1000	12.5 x 30	01	118 15102	118 25102	–	–
	1500	12.5 x 30	01	118 15152	118 25152	–	–
	2200	15 x 30	02	118 15222	118 25222	–	118 45222
	3300	18 x 30	03	118 15332	–	–	118 45332
	4700	18 x 40	04	118 15472	–	–	118 45472
	6800	21 x 40	05	118 15682	–	–	118 45682
25	100	6.5 x 18	4	–	118 26101	118 36101	–
	150	8 x 18	5	–	118 26151	118 36151	–
	220	10 x 18	6	–	118 26221	118 36221	–
	330	10 x 25	7	–	118 26331	118 36331	–
	470	10 x 25	7	–	118 90508	118 90509	–
	470	10 x 30	00	118 16471	118 26471	–	–
	680	12.5 x 30	01	118 16681	118 26681	–	–
	1000	12.5 x 30	01	118 16102	118 26102	–	–
	1500	15 x 30	02	118 16152	118 26152	–	118 46152
	2200	18 x 30	03	118 16222	–	–	118 46222
	3300	18 x 40	04	118 16332	–	–	118 46332
	4700	21 x 40	05	118 16472	–	–	118 46472
40	47	6.5 x 18	4	–	118 27479	118 37479	–
	68	8 x 18	5	–	118 27689	118 37689	–
	100	8 x 18	5	–	118 27101	118 37101	–
	150	10 x 18	6	–	118 27151	118 37151	–
	220	10 x 25	7	–	118 90511	118 90512	–
	220	10 x 30	00	118 17221	118 27221	–	–
	330	12.5 x 30	01	118 17331	118 27331	–	–
	470	12.5 x 30	01	118 17471	118 27471	–	–
	680	15 x 30	02	118 17681	118 27681	–	118 47681
	1000	18 x 30	03	118 17102	–	–	118 47102
	1500	18 x 40	04	118 17152	–	–	118 47152
	2200	21 x 40	05	118 17222	–	–	118 47222

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 125 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
63	1.0	6.5 x 18	16.4	20	4.1	0.07	110	22
	2.2	6.5 x 18	24.3	20	4.3	0.07	51	15
	4.7	6.5 x 18	35.6	20	4.6	0.07	24	8.9
	10	6.5 x 18	51.9	20	5.3	0.07	11	5.6
	15	6.5 x 18	63.6	20	5.9	0.07	7.4	4.2
	22	6.5 x 18	77.0	20	6.8	0.07	5.1	3.2
	33	8 x 18	106	20	8.2	0.07	3.4	2.1
	47	8 x 18	126	22	9.9	0.07	2.4	1.5
	68	10 x 18	175	30	13	0.07	1.6	1.1
	100	10 x 25	243	42	17	0.07	1.1	0.7
	100	10 x 30	262	42	17	0.07	1.1	1.0
	150	12.5 x 30	415	61	23	0.07	0.65	0.61
	220	12.5 x 30	454	87	32	0.08	0.61	0.56
	330	15 x 30	544	129	46	0.09	0.42	0.40
	470	18 x 30	695	182	63	0.09	0.31	0.33
	680	18 x 40	971	261	90	0.09	0.2	0.18
	1000	21 x 40	1161	383	130	0.10	0.16	0.15
100	4.7	6.5 x 18	36	20	4.9	0.07	24	19
	10	6.5 x 18	52	20	6.0	0.07	11	9.0
	15	8 x 18	79	20	7.0	0.07	7.4	6.0
	22	8 x 18	91	20	8.4	0.07	5.1	4.0
	33	10 x 25	140	24	11	0.07	3.4	2.7
	47	10 x 25	170	33	13	0.07	2.6	2.0
	47	10 x 30	178	33	13	0.08	2.6	2.0
	68	12.5 x 30	278	45	18	0.08	1.8	1.2
	100	12.5 x 30	303	64	24	0.09	1.4	1.15
	150	15 x 30	368	94	34	0.10	0.94	0.78
	220	18 x 30	481	136	48	0.10	0.66	0.55
	330	18 x 40	694	202	70	0.10	0.45	0.37
	470	21 x 40	833	286	98	0.10	0.33	0.28

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
63	1.0	6.5 x 18	4	–	118 28108	118 38108	–
	2.2	6.5 x 18	4	–	118 28228	118 38228	–
	4.7	6.5 x 18	4	–	118 28478	118 38478	–
	10	6.5 x 18	4	–	118 28109	118 38109	–
	15	6.5 x 18	4	–	118 28159	118 38159	–
	22	6.5 x 18	4	–	118 28229	118 38229	–
	33	8 x 18	5	–	118 28339	118 38339	–
	47	8 x 18	5	–	118 28479	118 38479	–
	68	10 x 18	6	–	118 28689	118 38689	–
	100	10 x 25	7	–	118 90513	118 90514	–
	100	10 x 30	00	118 18101	118 28101	–	–
	150	12.5 x 30	01	118 18151	118 28151	–	–
	220	12.5 x 30	01	118 18221	118 28221	–	–
	330	15 x 30	02	118 18331	118 28331	–	118 48331
	470	18 x 30	03	118 18471	–	–	118 48471
	680	18 x 40	04	118 18681	–	–	118 48681
	1000	21 x 40	05	118 18102	–	–	118 48102
100	4.7	6.5 x 18	4	–	118 29478	118 39478	–
	10	6.5 x 18	4	–	118 29109	118 39109	–
	15	8 x 18	5	–	118 29159	118 39159	–
	22	8 x 18	5	–	118 29229	118 39229	–
	33	10 x 25	7	–	118 29339	118 39339	–
	47	10 x 25	7	–	118 90535	118 90536	–
	47	10 x 30	00	118 19479	118 29479	–	–
	68	12.5 x 30	01	118 19689	118 29689	–	–
	100	12.5 x 30	01	118 19101	118 29101	–	–
	150	15 x 30	02	118 19151	118 29151	–	118 49151
	220	18 x 30	03	118 19221	–	–	118 49221
	330	18 x 40	04	118 19331	–	–	118 49331
	470	21 x 40	05	118 19471	–	–	118 49471

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 125 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
200	2.2	6.5 x 18	27	20	4.9	0.06	44	23
	4.7	8 x 18	46	20	5.9	0.06	21	11
	10	10 x 25	85	20	8.0	0.06	9.4	5.0
	15	10 x 30	129	22	10	0.046	4.76	3.75
	22	12.5 x 30	198	31	13	0.046	3.17	2.22
	33	15 x 30	242	44	17	0.046	2.11	1.11
	47	18 x 30	317	61	23	0.046	1.48	0.60
	68	18 x 40	428	86	31	0.046	1.02	0.42
	100	21 x 40	551	124	44	0.046	0.96	0.39

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
200	2.2	6.5 x 18	4	–	118 90537	118 90538	–
	4.7	8 x 18	5	–	118 90539	118 90541	–
	10	10 x 25	7	–	118 90542	118 90543	–
	15	10 x 30	00	118 92159	118 90012	–	–
	22	12.5 x 30	01	118 92229	118 90013	–	–
	33	15 x 30	02	118 92339	118 90014	–	118 90002
	47	18 x 30	03	118 92479	–	–	118 90003
	68	18 x 40	04	118 92689	–	–	118 90004
	100	21 x 40	05	118 92101	–	–	118 90006

Marking

The capacitors are marked (where possible) with the following information:

- Rated capacitance in µF
- Tolerance on rated capacitance, code letter in accordance with IEC 62
- Rated voltage in V (at 125 °C and at 85 °C)
- Group number (118)
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Code indicating factory of origin
- Band to identify the negative terminal
- "+" - signs to identify the positive terminal.

Voltage

Surge voltage for short periods — $U_s \leq 1.15 \times U_R$

Reverse voltage — $U_{rev} \leq 1$ V

Note

For applications at ambient temperatures of ≤85 °C, the rated voltage (U_R) may be raised to U_{R2} in accordance with Table 6.

Table 6 Uprating values at reduced ambient temperature

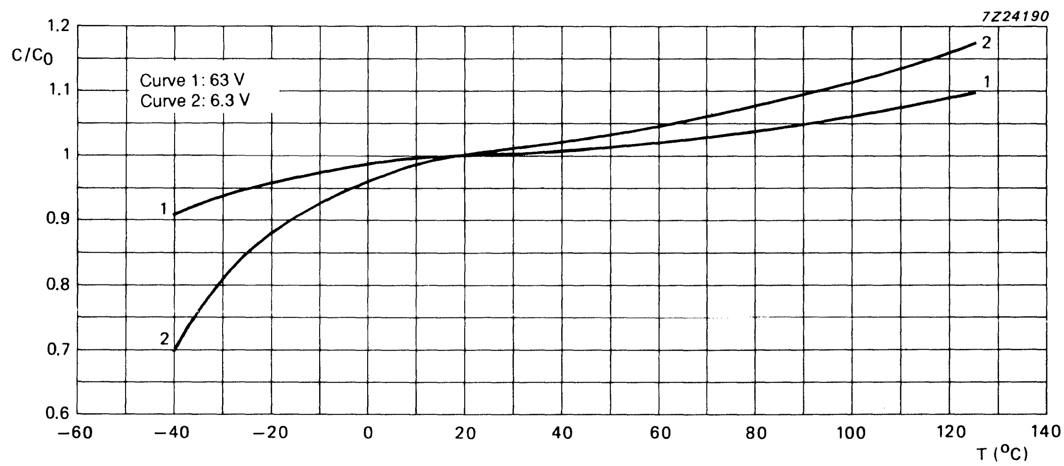
U_R at T_{amb} 85 to 125 °C	6.3 V	10 V	16 V	25 V	40 V	63 V	100 V	200 V
U_{R2} at T_{amb} ≤85 °C	10 V	16 V	25 V	40 V	63 V	100 V	125 V	250 V

Leakage current

After 1 minute at U_R — $I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$ or 20 µA (whichever is greater)

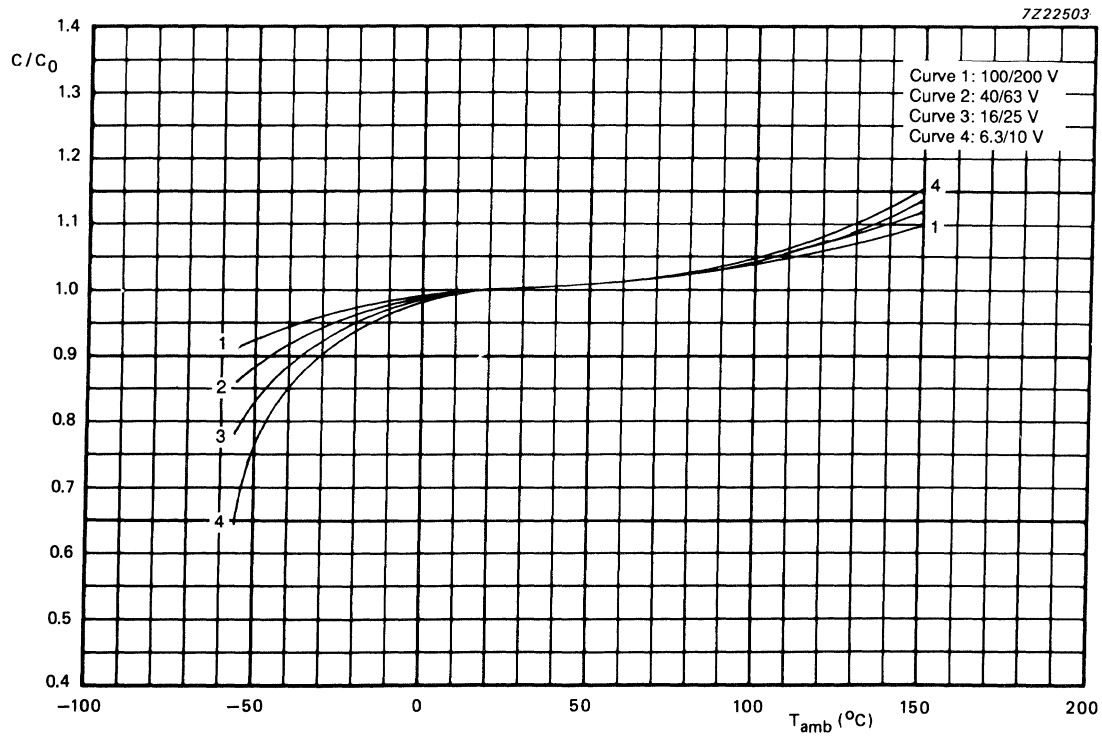
After 5 minutes at U_R — $I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$

Capacitance (C)



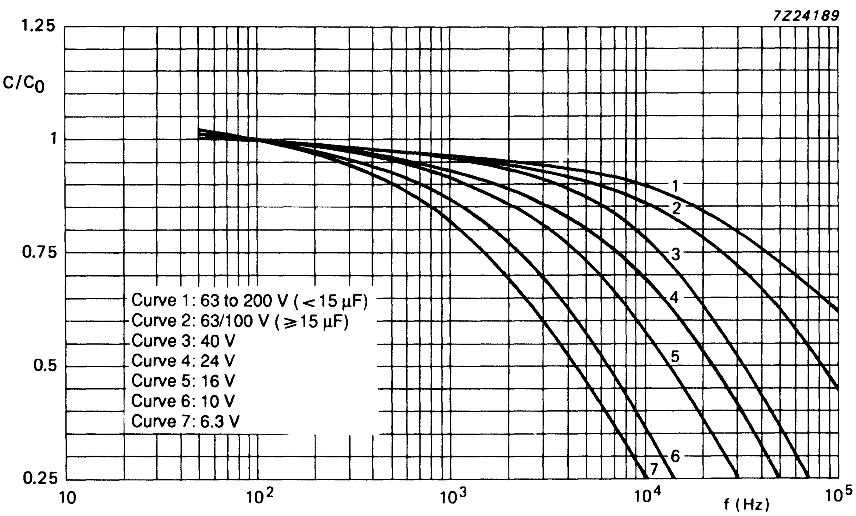
C_0 = capacitance at 20 °C, 100 Hz.

Fig.5 Multiplier of capacitance (C/C_0) as a function of ambient temperature; case sizes 6.5 x 18 to 10 x 25.



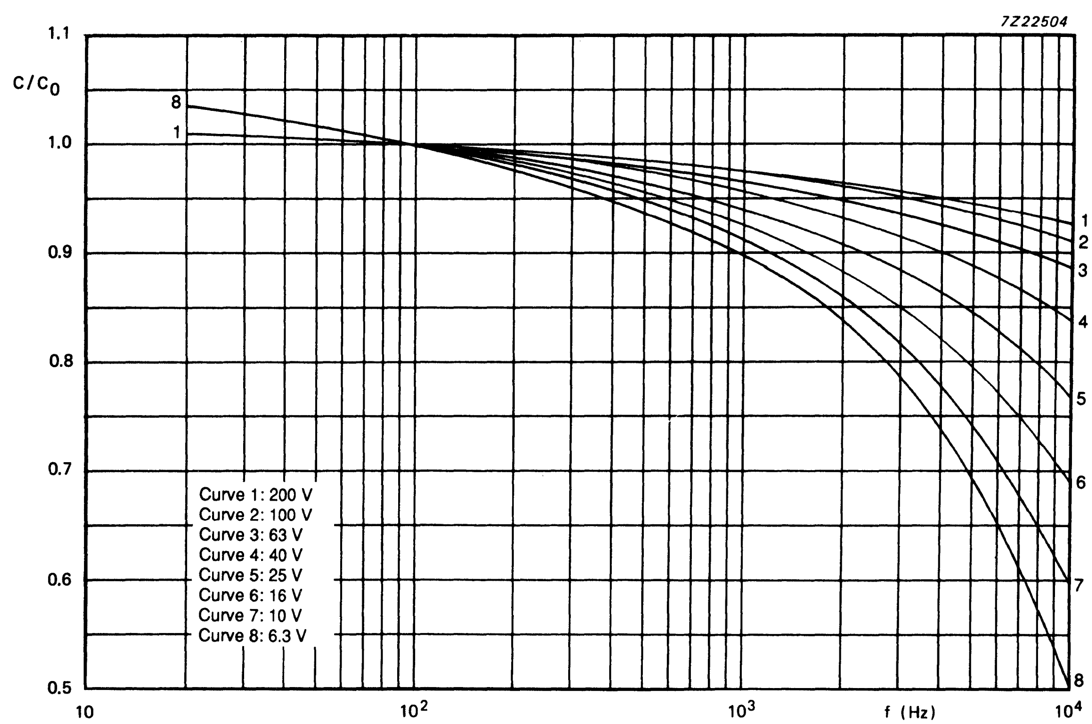
C_0 = capacitance at 20 °C, 100 Hz.

Fig.6 Multiplier of capacitance (C/C_0) as a function of ambient temperature; case sizes 10 x 30 to 21 x 40.



C_0 = capacitance at 20 °C; 100 Hz.

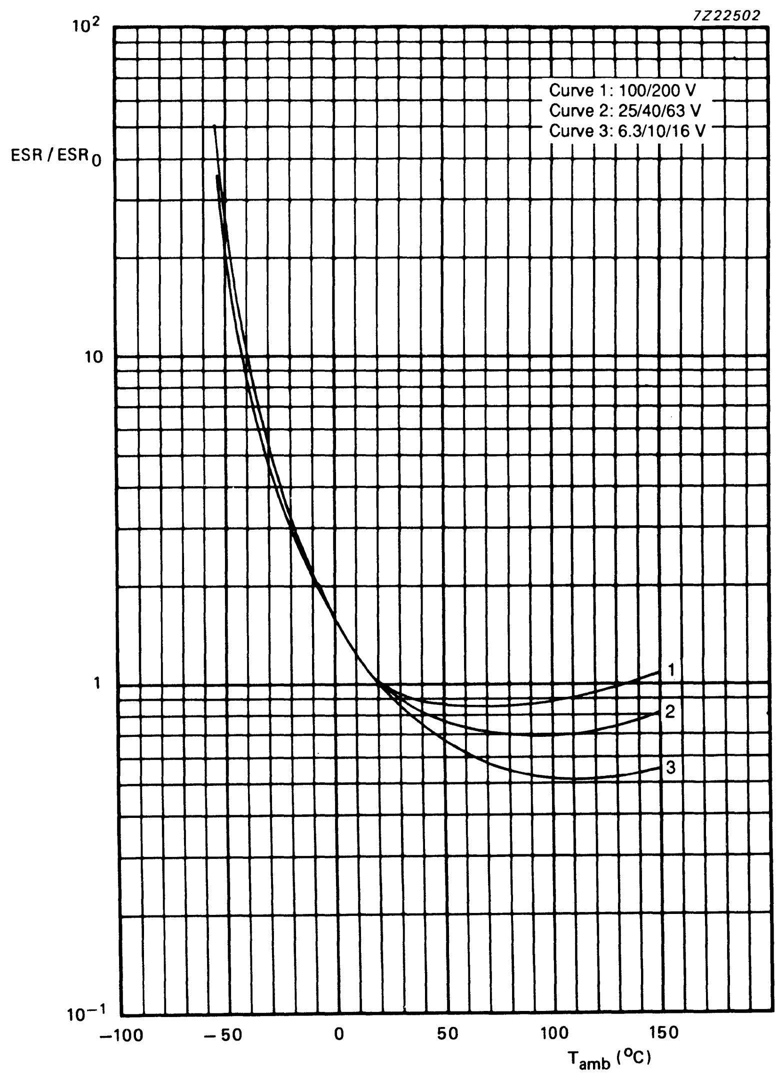
Fig.7 Multiplier of capacitance (C/C_0) as a function of frequency; case sizes 6.5 x 18 to 10 x 25.



C_0 = capacitance at 20 °C; 100 Hz.

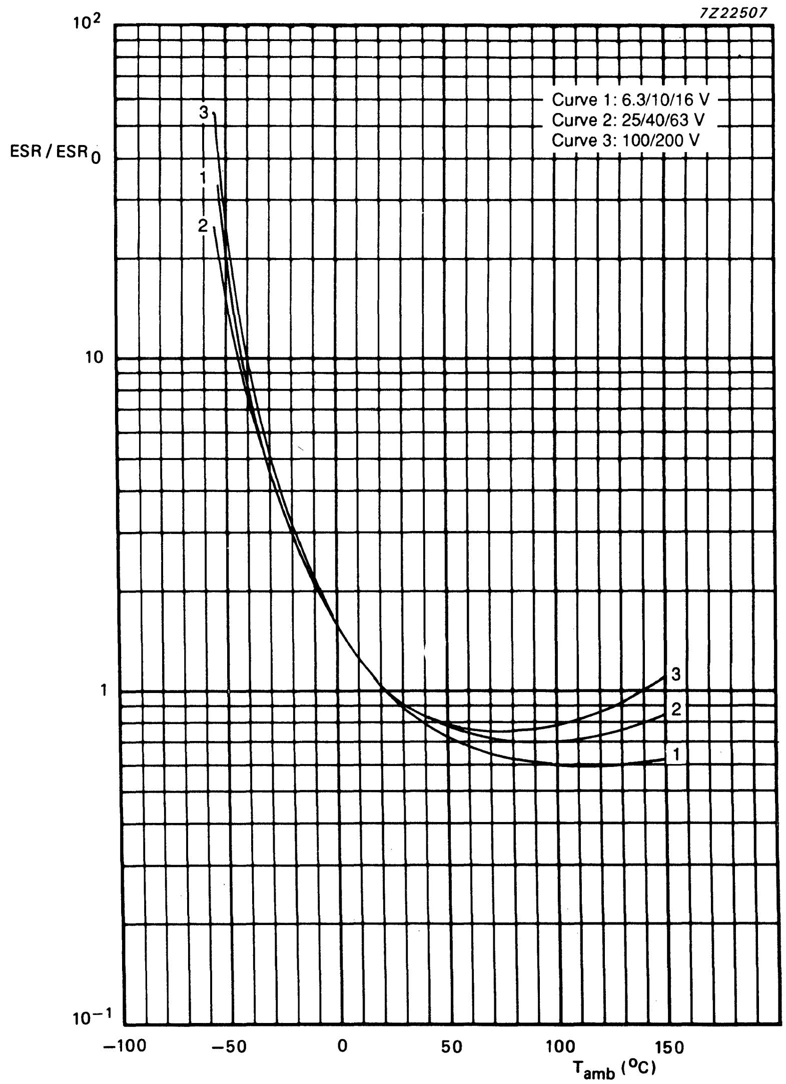
Fig.8 Multiplier of capacitance (C/C_0) as a function of frequency; case sizes 10 x 30 to 21 x 40.

Equivalent series resistance (ESR)



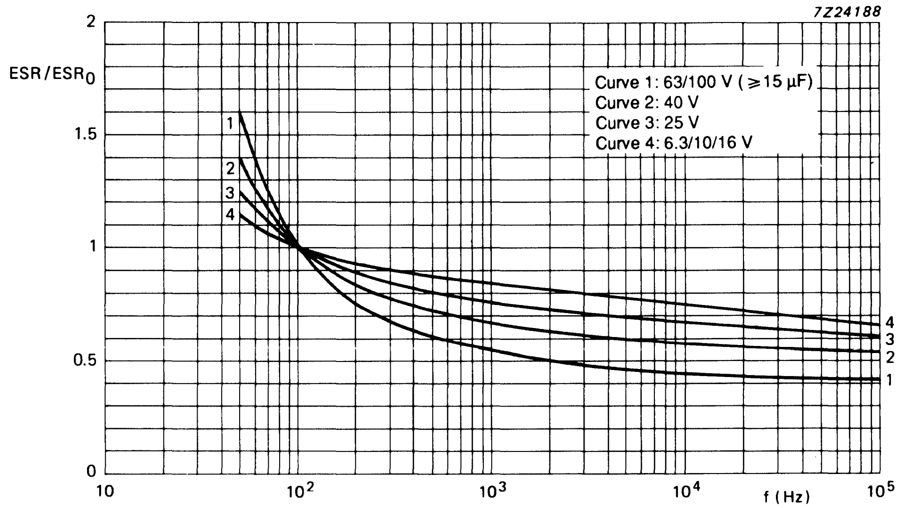
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.9 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; case sizes 6.5 x 18 to 15 x 30 mm.



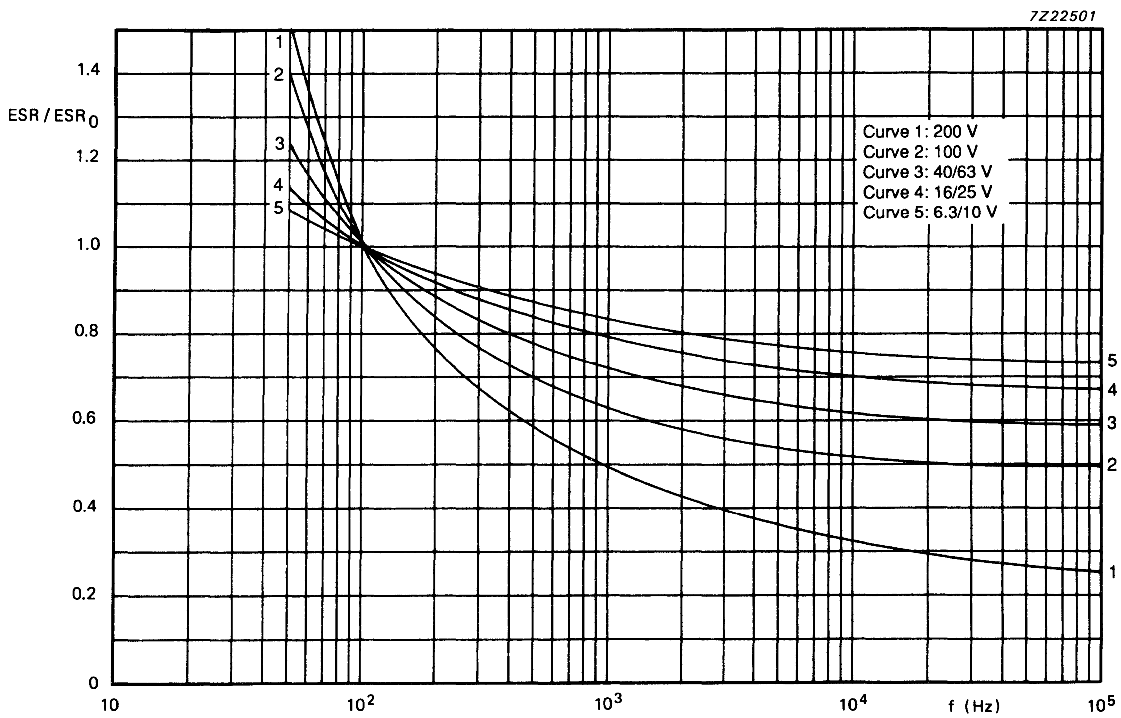
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.10 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; case sizes 18 x 30 mm to 21 x 40 mm.



ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.11 Multiplier of ESR (ESR/ESR_0) as a function of frequency; case sizes 6.5 x 18 to 10 x 25 mm.



ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.12 Multiplier of ESR (ESR/ESR_0) as a function of frequency; case sizes 10 x 30 to 21 x 40 mm.

Equivalent series inductance (ESL)

Table 7 Equivalent series inductance, typical values

CASE SIZE ∅ x L (mm)	AXIAL (nH)	SINGLE ENDED (nH)
6.5 x 18	15	–
8 x 18	35	–
10 x 18	69	–
10 x 25	38	–
10 x 30	38	–
12.5 x 30	46	–
15 x 30	48	39
18 x 30	50	39
18 x 40	54	39
21 x 40	59	39

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Impedance (Z)

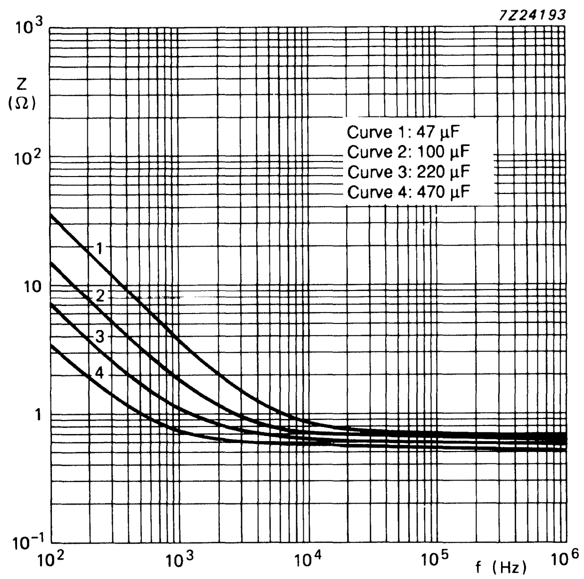


Fig.13 Typical impedance as a function of frequency at 20 °C; case size 8 x 18.

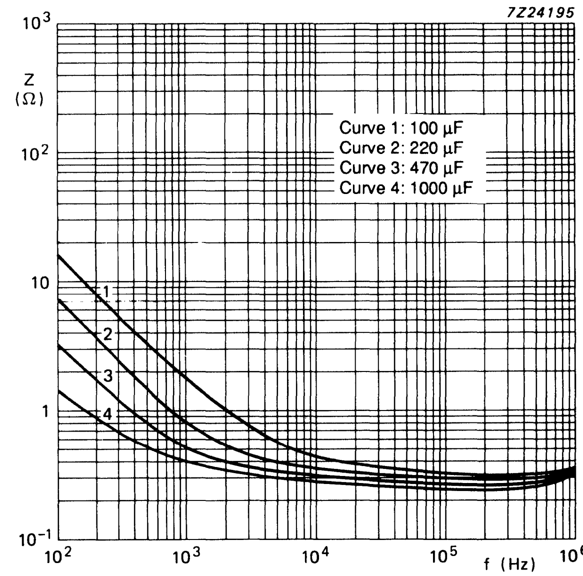


Fig.14 Typical impedance as a function of frequency at 20 °C; case size 10 x 25.

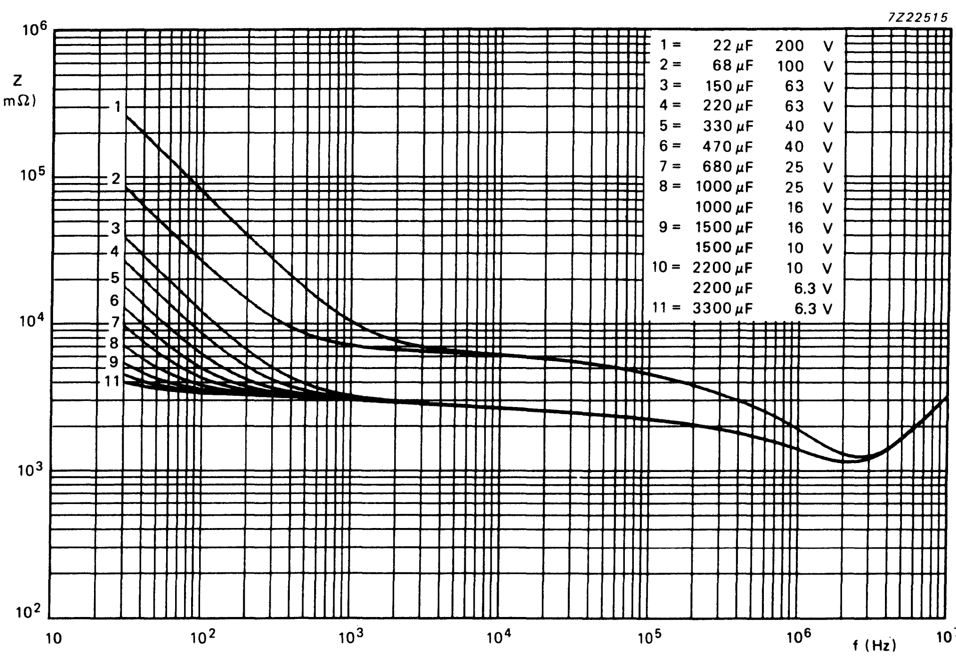


Fig.15 Typical impedance as a function of frequency at –40 °C; case size 12.5 x 30.

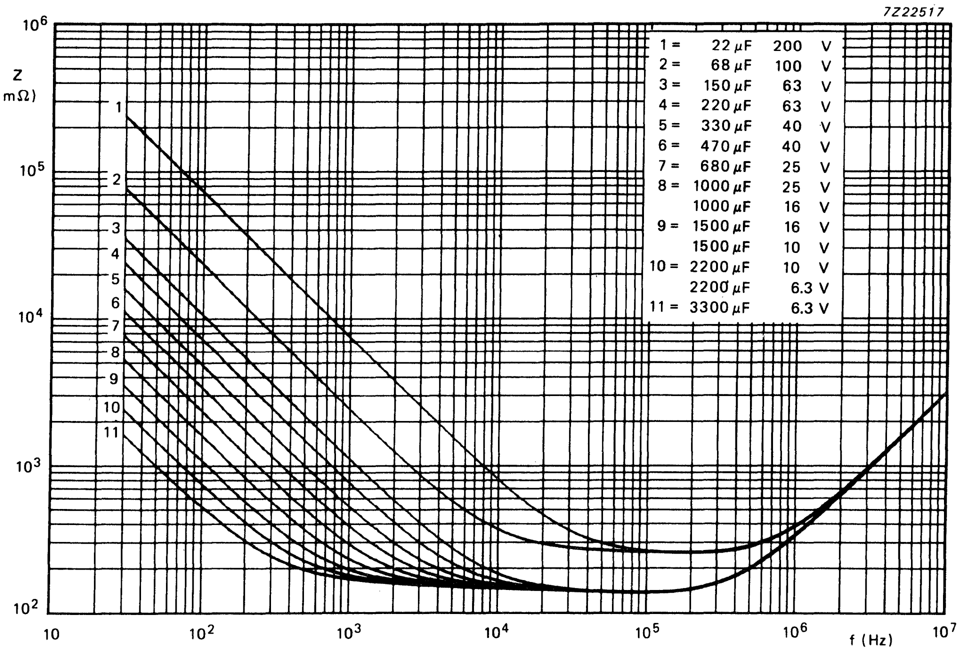


Fig.16 Typical impedance as a function of frequency at 20 °C; case size 12.5 x 30.

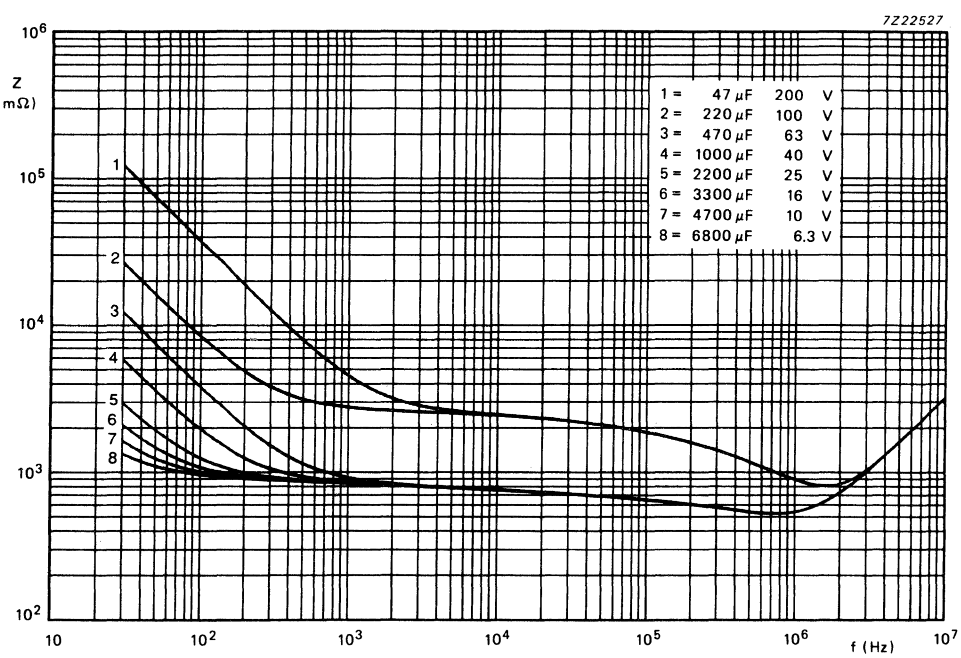


Fig.17 Typical impedance as a function of frequency at –40 °C; case size 18 x 30.

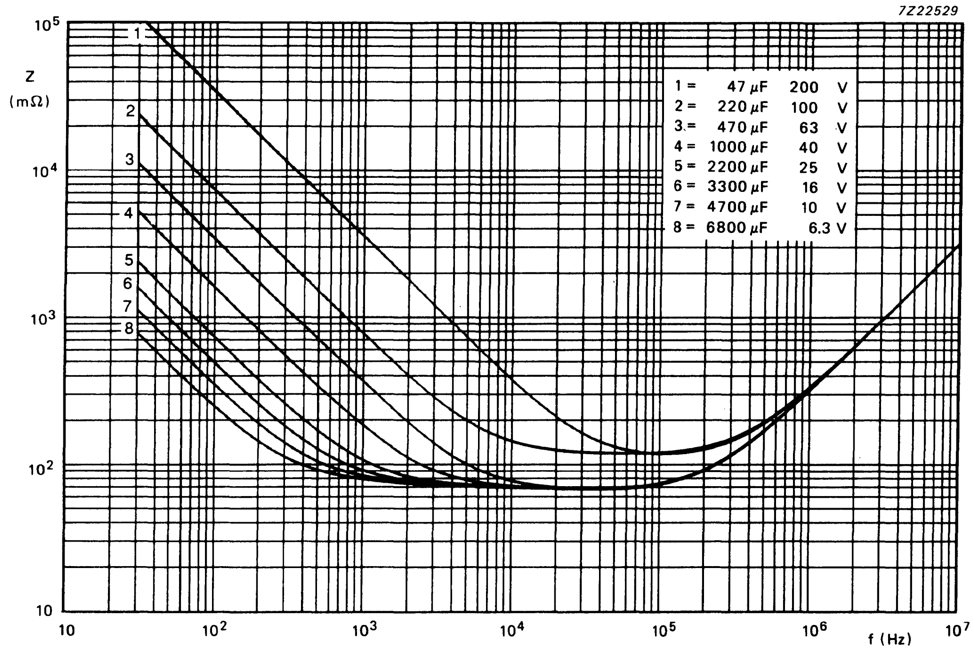
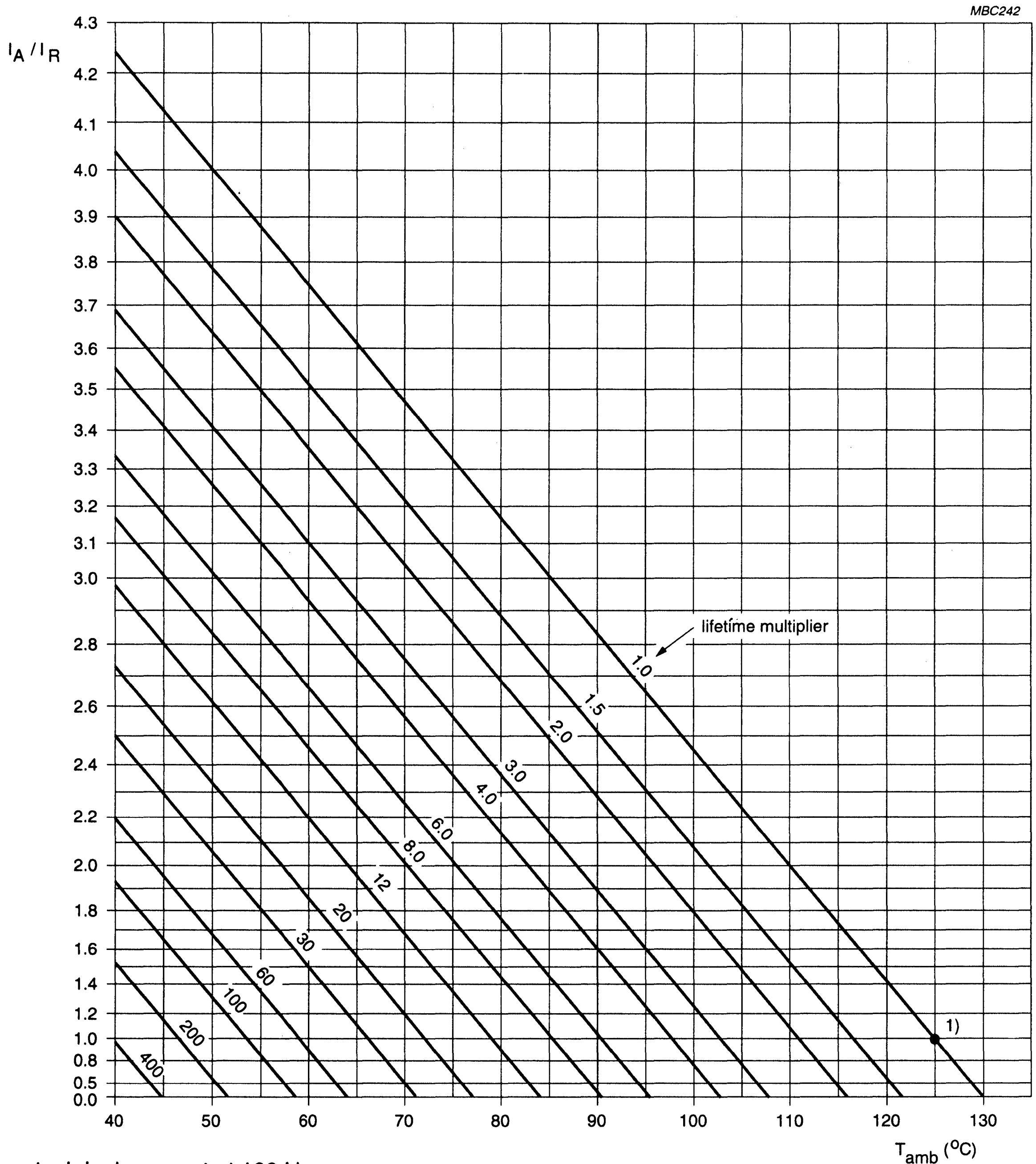


Fig.18 Typical impedance as a function of frequency at 20 °C; case size 18 x 30.

RIPPLE CURRENT and USEFUL LIFE



I_A = actual ripple current at 100 Hz.

I_R = rated ripple current at 100 Hz, 125 °C.

1) Useful life at 125 °C and I_R applied: 4000 hours.

Fig.19 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

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Table 8 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 125 °C, 100 Hz.

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 to 25 V	U_R = 40 to 63 V	U_R = 100 to 200 V
50	0.95	0.9	0.85
100	1.0	1.0	1.0
300	1.07	1.12	1.2
1000	1.12	1.2	1.3
3000	1.15	1.25	1.35
≥10 000	1.2	1.3	1.4

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 9

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	Reference		
Endurance	IEC 384-4-1/ CECC 30 301 group C 3, 4.13	T_{amb} = 125 °C, U_R applied case sizes: 6.5 x 18 to 10 x 25: 2000 hours 10 x 30 to 21 x 40: 3000 hours	U_R ≤6.3 V : ΔC/C +15/−30% U_R >6.3 V : ΔC/C ±15% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 125 °C, U_R and I_R applied 4000 hours	U_R ≤6.3 V : ΔC/C +45/−50% U_R >6.3 V : ΔC/C ±45% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤1%
Shelf life (Storage at high temp.)	IEC 384-4-1/ CECC 30 301 group C 5a, 4.17	T_{amb} = 125 °C, no voltage applied U_R 6.3 to 63 V: 500 hours U_R 100 and 200 V: 100 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit
Reverse voltage	IEC 384-4-1/ CECC 30 301 sub clause 4.15	T_{amb} = 125 °C: 125 hours at U = −1 V followed by 125 hours at U_R	ΔC/C ±20% tan δ ≤spec. limit I_{L5} ≤spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Axial leads, cylindrical aluminium case, insulated with a blue sleeve
- Mounting ring version (single ended) not insulated
- Case sizes 10 x 30 to 21 x 40 with safety vent
- Taped versions up to 15 x 30 available for automatic insertion
- Charge and discharge proof
- Extra long useful life: 4000 hours at 125 °C, high stability, high reliability
- Extended temperature range: 125 °C (usable up to 150 °C)
- High ripple current capability.

APPLICATIONS

- Military, industrial control, EDP and telecommunication
- Smoothing, filtering, buffering in SMPS; coupling, decoupling
- For use after very long storage (10 years), without voltage
- Low mounting height boards, vibration and shock resistant.

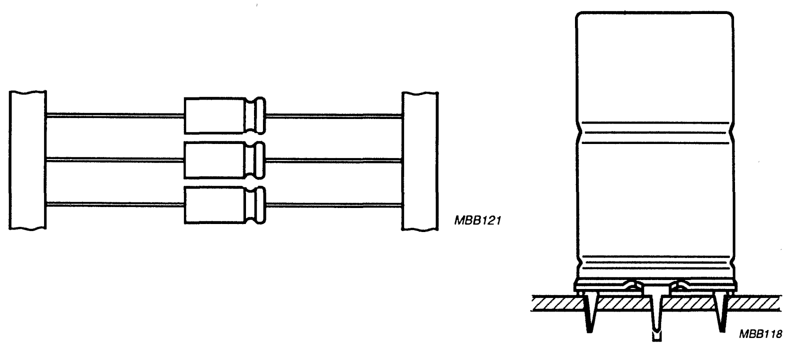


Fig.1 Component outlines.

QUICK REFERENCE DATA

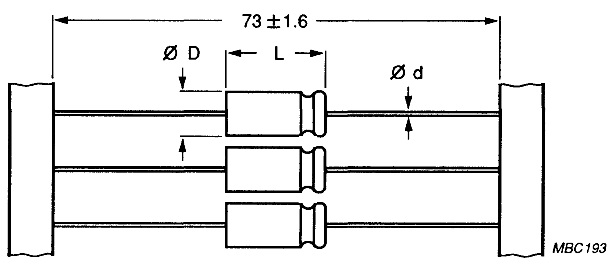
Case sizes (∅ D_{nom} x L_{nom} in mm)	6.5 x 18 to 10 x 25	10 x 30 to 21 x 40
Rated capacitance range, C_R	1 to 4700 µF	
Tolerance on C_R	−10/+50%	
Rated voltage range, U_R	10 to 200 V	
Category temperature range	−55 to +125 °C	
Endurance test at 150 °C	500 hours	1000 hours
Endurance test at 125 °C	2000 hours	4000 hours
Useful life at 125 °C	4000 hours	4000 hours
Useful life at 40 °C, 1.8 I_R applied	500 000 hours	500 000 hours
Shelf life at 0 V, 125 °C 10 to 63 V types 100 and 200 V types	 500 hours 100 hours	
Basic specification	IEC 384-4/CECC 30 301, LL grade	
Detail specification	similar to DIN 41257	
Climatic category IEC 68 DIN 40040	 55/125/56 FKD	
Approvals	CECC 30 301-055 (values ≥4.7 µF)	CECC 30 301-802 (axial version 10 to 63 V types)

Table 1 Selection chart for C_RU_R and relevant nominal case sizes (∅ **D x L** in **mm**)   ∗ = preferred values

C_R (µF)	U_R (V)						
	10	**16**	**25**	**40**	**63**	**100**	**200**
1.0					6.5 x 18 ∗		
2.2					6.5 x 18 ∗		
4.7					6.5 x 18 ∗	6.5 x 18∗	10 x 18 ∗
10					6.5 x 18 ∗	8 x 18∗	10 x 25 ∗
15				6.5 x 18	8 x 18	10 x 18	
22			6.5 x 18 ∗		8 x 18 ∗	10 x 18 ∗	
33				8 x 18	10 x 18		
47		6.5 x 18 ∗		8 x 18 ∗	10 x 18 ∗	10 x 25 ∗ 10 x 30 ∗	
68				10 x 18	10 x 25 10 x 30	12.5 x 30	
100	6.5 x 18 ∗	8 x 18 ∗	10 x 18 ∗	10 x 25 ∗	10 x 30 ∗	15 x 30 ∗	
150		10 x 18	10 x 25	12.5 x 30	15 x 30	15 x 30	
220	10 x 18 ∗	10 x 25 ∗	10 x 25 ∗ 12.5 x 30 ∗	12.5 x 30 ∗	15 x 30 ∗	18 x 30 ∗	
330	10 x 25 ∗	12.5 x 30 ∗	12.5 x 30 ∗	15 x 30 ∗	18 x 30 ∗	18 x 40 ∗	
470	10 x 25 ∗ 12.5 x 30 ∗	12.5 x 30 ∗	12.5 x 30 ∗	15 x 30 ∗	18 x 40 ∗	21 x 40 ∗	
680	12.5 x 30 ∗	15 x 30 ∗	18 x 30 ∗	18 x 30 ∗	21 x 40 ∗		
1000	15 x 30 ∗	15 x 30 ∗	18 x 30 ∗	18 x 40 ∗	21 x 40 ∗		
1500	18 x 30 ∗	18 x 30 ∗	18 x 40 ∗	21 x 40 ∗			
2200	18 x 30 ∗	18 x 40 ∗	21 x 40 ∗	21 x 40 ∗			
3300	18 x 40 ∗	21 x 40 ∗					
4700	21 x 40 ∗	21 x 40 ∗					

MECHANICAL DATA, PACKING QUANTITIES and AVAILABLE FORMS

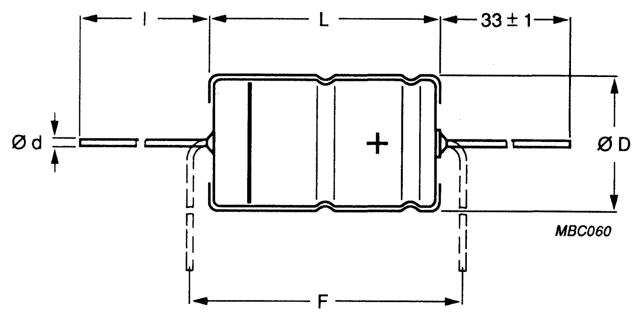
Dimensions in mm.
Tape dimensions are specified in chapter "PACKING",



Form BR: Taped on reel, case sizes 6.5 x 18 to 15 x 30.

Form BA: Taped in box (ammopack), case sizes 6.5 x 18 to 10 x 25.

Fig.2 Case sizes 6.5 x 18 to 15 x 30.



Form AA: Axial in box.

Fig.3 Case sizes 10 x 30 to 21 x 40.

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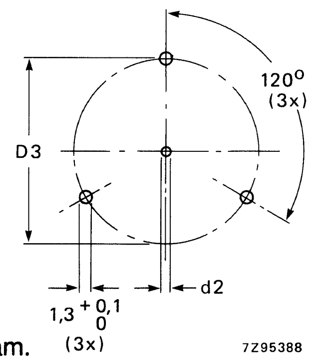
Table 2 Axial, dimensions in mm; mass in g

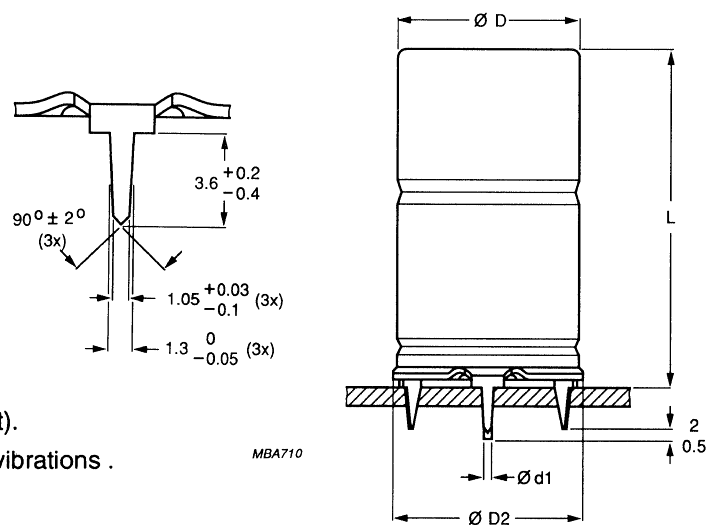
CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	AXIAL: Form AA, BA, and BR					APPROX. MASS	PACKING QUANTITIES		
		Ød	l	ØD_{max}	L_{max}	F_{min}		Form AA	Form BA	Form BR
6.5 x 18	4	0.8	–	6.9	18.5	25	1.3	–	1000	1000
8 x 18	5	0.8	–	8.5	18.5	25	1.7	–	500	500
10 x 18	6	0.8	–	10.5	18.5	25	2.5	–	500	500
10 x 25	7	0.8	–	10.5	25.0	30	3.3	–	500	500
10 x 30	00	0.8	55 ±1	10.5	30.5	35	4.8	200	–	500
12.5 x 30	01	0.8	55 ±1	13.0	30.5	35	7.4	200	–	400
15 x 30	02	0.8	55 ±1	15.5	30.5	35	11.7	200	–	250
18 x 30	03	0.8	55 ±1	18.5	30.5	35	12.9	200	–	–
18 x 40 (note 1)	04	0.8	34 ±1	18.5	41.5	45	19.4	100	–	–
21 x 40 (note 1)	05	0.8	34 ±1	21.5	41.5	45	24.7	100	–	–

Note

1. For case sizes 18 x 40 and 21 x 40, the stated L_{max} may be exceeded by 0.7 mm.



Piercing diagram.



Form MR: case not insulated (insulation on request).
Especially for applications with severe shocks and vibrations .
For dimensions see Table 3.

Fig.4 Case sizes 15 x 30 to 21 x 40, single ended with mounting ring and pins.

Table 3 Single ended, dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	SINGLE ENDED WITH MOUNTING RING: Form MR						APPROX. MASS	PACKING QUANTITIES
		Ød_1	Ød_2	ØD_{max}	Ø$D2_{max}$	D3	L_{max}		
15 x 30	02	0.8	1.0 +0.1	15.5	17.5	16.5 ±0.2	33	8.6	200
18 x 30	03	0.8	1.0 +0.1	18.5	19.5	18.5 ±0.2	33	11.5	200
18 x 40	04	1.0	1.3 +0.1	18.5	19.5	18.5 ±0.2	45	14.5	100
21 x 40	05	1.0	1.3 +0.1	21.5	22.5	21.5 ±0.2	45	19.7	100

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 4 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz, tolerance 2222 119 . . . . .
I_R	= rated RMS ripple current at 100 Hz, 125 °C
I_{L1}	= max. leakage current after 1 minute at U_R
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	= max. impedance at 10 kHz.

Table 4 Electrical data

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 125 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
10	100	6.5 x 18	130	10	6	0.2	3.5	2.2
	220	10 x 18	240	17	8.4	0.18	1.3	1.0
	330	10 x 25	320	24	11	0.18	0.87	0.67
	470	10 x 25	380	32	13	0.18	0.61	0.49
	470	12.5 x 30	550	32	13	0.16	0.54	0.38
	680	12.5 x 30	590	45	18	0.20	0.47	0.38
	1000	15 x 30	715	64	24	0.20	0.32	0.24
	1500	18 x 30	945	94	34	0.22	0.23	0.17
	2200	18 x 30	1025	136	48	0.26	0.19	0.17
	3300	18 x 40	1405	202	70	0.27	0.13	0.10
	4700	21 x 40	1700	286	90	0.30	0.10	0.09
16	47	6.5 x 18	110	10	5.5	0.13	4.4	2.2
	100	8 x 18	170	14	7.2	0.13	2.1	1.3
	150	10 x 18	230	18	8.8	0.13	1.4	1.0
	220	10 x 25	300	25	11	0.13	0.94	0.55
	330	12.5 x 30	510	36	15	0.13	0.63	0.38
	470	12.5 x 30	565	50	19	0.15	0.51	0.38
	680	15 x 30	680	69	26	0.15	0.35	0.24
	1000	15 x 30	735	100	36	0.19	0.30	0.24
	1500	18 x 30	970	148	52	0.20	0.21	0.17
	2200	18 x 40	1310	215	74	0.20	0.14	0.10
	3300	21 x 40	1650	321	110	0.22	0.11	0.09
	4700	21 x 40	1700	455	154	0.28	0.09	0.09

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 119 .....
470 µF/16 V, −10/+50%
Case size 12.5 x 30; Form BR
Catalogue number: 2222 119 25471.

Table 5 Ordering Information

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
10	100	6.5 x 18	4	–	119 24101	119 34101	–
	220	10 x 18	6	–	119 24221	119 34221	–
	330	10 x 25	7	–	119 24331	119 34331	–
	470	10 x 25	7	–	119 90501	119 90502	–
	470	12.5 x 30	01	119 14471	119 24471	–	–
	680	12.5 x 30	01	119 14681	119 24681	–	–
	1000	15 x 30	02	119 14102	119 24102	–	119 44102
	1500	18 x 30	03	119 14152	–	–	119 44152
	2200	18 x 30	03	119 14222	–	–	119 44222
	3300	18 x 40	04	119 14332	–	–	119 44332
	4700	21 x 40	05	119 14472	–	–	119 44472
16	47	6.5 x 18	4	–	119 25479	119 35479	–
	100	8 x 18	5	–	119 25101	119 35101	–
	150	10 x 18	6	–	119 25151	119 35151	–
	220	10 x 25	7	–	119 25221	119 35221	–
	330	12.5 x 30	01	119 15331	119 25331	–	–
	470	12.5 x 30	01	119 15471	119 25471	–	–
	680	15 x 30	02	119 15681	119 25681	–	119 45681
	1000	15 x 30	02	119 15102	119 25102	–	119 45102
	1500	18 x 30	03	119 15152	–	–	119 45152
	2200	18 x 40	04	119 15222	–	–	119 45222
	3300	21 x 40	05	119 15332	–	–	119 45332
	4700	21 x 40	05	119 15472	–	–	119 45472

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 125 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
25	22	6.5 x 18	85	10	5.1	0.10	7.2	3.2
	100	10 x 18	210	19	9	0.10	1.6	1.0
	150	10 x 25	290	26	12	0.10	1.1	0.70
	220	10 x 25	350	37	15	0.10	0.72	0.58
	220	12.5 x 30	500	37	15	0.09	0.65	0.38
	330	12.5 x 30	555	54	21	0.11	0.53	0.38
	470	12.5 x 30	610	75	28	0.13	0.44	0.38
	680	18 x 30	810	106	38	0.13	0.30	0.17
	1000	18 x 30	980	154	54	0.13	0.21	0.17
	1500	18 x 40	1345	229	79	0.13	0.14	0.10
	2200	21 x 40	1640	334	114	0.13	0.11	0.09
40	15	6.5 x 18	78	10	5.2	0.08	8.5	5.0
	33	8 x 18	130	12	6.6	0.08	3.9	2.1
	47	8 x 18	150	15	7.8	0.08	2.7	1.5
	68	10 x 18	200	20	9.4	0.08	1.9	1.0
	100	10 x 25	260	28	12	0.08	1.3	0.7
	150	12.5 x 30	440	40	16	0.08	0.85	0.51
	220	12.5 x 30	500	57	22	0.09	0.65	0.48
	330	15 x 30	615	83	30	0.09	0.43	0.37
	470	15 x 30	630	117	42	0.12	0.41	0.37
	680	18 x 30	845	167	58	0.12	0.28	0.22
	1000	18 x 40	1140	244	84	0.12	0.19	0.14
	1500	21 x 40	1400	364	124	0.14	0.15	0.12
	2200	21 x 40	1490	532	180	0.18	0.13	0.11

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
25	22	6.5 x 18	4	–	119 26229	119 36229	–
	100	10 x 18	6	–	119 26101	119 36101	–
	150	10 x 25	7	–	119 26151	119 36151	–
	220	10 x 25	7	–	119 90503	119 90504	–
	220	12.5 x 30	01	119 16221	119 26221	–	–
	330	12.5 x 30	01	119 16331	119 26331	–	–
	470	12.5 x 30	01	119 16471	119 26471	–	–
	680	18 x 30	03	119 16681	–	–	119 46681
	1000	18 x 30	03	119 16102	–	–	119 46102
	1500	18 x 40	04	119 16152	–	–	119 46152
	2200	21 x 40	05	119 16222	–	–	119 46222
40	15	6.5 x 18	4	–	119 27159	119 37159	–
	33	8 x 18	5	–	119 27339	119 37339	–
	47	8 x 18	5	–	119 27479	119 37479	–
	68	10 x 18	6	–	119 27689	119 37689	–
	100	10 x 25	7	–	119 27101	119 37101	–
	150	12.5 x 30	01	119 17151	119 27151	–	–
	220	12.5 x 30	01	119 17221	119 27221	–	–
	330	15 x 30	02	119 17331	119 27331	–	119 47331
	470	15 x 30	02	119 17471	119 27471	–	119 47471
	680	18 x 30	03	119 17681	–	–	119 47681
	1000	18 x 40	04	119 17102	–	–	119 47102
	1500	21 x 40	05	119 17152	–	–	119 47152
	2200	21 x 40	05	119 17222	–	–	119 47222

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 125 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
63	1.0	6.5 x 18	12	20	4.1	0.07	110	22.0
	2.2	6.5 x 18	25	20	4.3	0.07	51	15.0
	4.7	6.5 x 18	47	20	4.6	0.07	24	9.0
	10	6.5 x 18	68	20	5.3	0.07	11	5.6
	15	8 x 18	91	20	5.9	0.07	7.4	3.7
	22	8 x 18	110	20	6.7	0.07	5.1	2.8
	33	10 x 18	150	20	8.2	0.07	3.4	1.7
	47	10 x 18	180	22	9.9	0.07	2.4	1.3
	68	10 x 25	230	30	13	0.07	1.6	1.0
	68	10 x 30	250	30	13	0.07	1.6	0.92
	100	10 x 30	285	42	17	0.08	1.3	0.75
	150	15 x 30	440	61	23	0.08	0.85	0.37
	220	15 x 30	530	87	32	0.08	0.58	0.37
	330	18 x 30	680	129	46	0.09	0.43	0.23
	470	18 x 40	905	182	63	0.09	0.30	0.15
	680	21 x 40	1175	261	90	0.09	0.21	0.12
	1000	21 x 40	1385	382	130	0.10	0.16	0.11
100	4.7	6.5 x 18	44	20	10	0.08	27	10
	10	8 x 18	70	20	10	0.08	13	6.0
	15	10 x 18	93	20	10	0.08	8.5	5.0
	22	10 x 18	112	20	10	0.08	5.8	3.5
	47	10 x 25	178	32	13	0.08	2.7	2.0
	47	10 x 30	178	32	13	0.08	2.7	2.0
	68	12.5 x 30	278	45	18	0.08	1.9	1.2
	100	15 x 30	365	64	24	0.09	1.4	0.96
	150	15 x 30	368	94	34	0.10	1.1	0.78
	220	18 x 30	481	136	48	0.10	0.72	0.55
	330	18 x 40	694	202	70	0.10	0.48	0.37
	470	21 x 40	833	266	98	0.10	0.34	0.28
200	4.7	10 x 18	52	20	10	0.08	27	10
	10	10 x 25	82	20	10	0.08	13	5.0

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
63	1.0	6.5 x 18	4	–	119 28108	119 38108	–
	2.2	6.5 x 18	4	–	119 28228	119 38228	–
	4.7	6.5 x 18	4	–	119 28478	119 38478	–
	10	6.5 x 18	4	–	119 28109	119 38109	–
	15	8 x 18	5	–	119 28159	119 38159	–
	22	8 x 18	5	–	119 28229	119 38229	–
	33	10 x 18	6	–	119 28339	119 38339	–
	47	10 x 18	6	–	119 28479	119 38479	–
	68	10 x 25	7	–	119 90505	119 90506	–
	68	10 x 30	00	119 18689	119 28689	–	–
	100	10 x 30	00	119 18101	119 28101	–	–
	150	15 x 30	02	119 18151	119 28151	–	119 48151
	220	15 x 30	02	119 18221	119 28221	–	119 48221
	330	18 x 30	03	119 18331	–	–	119 48331
	470	18 x 40	04	119 18471	–	–	119 48471
	680	21 x 40	05	119 18681	–	–	119 48681
	1000	21 x 40	05	119 18102	–	–	119 48102
100	4.7	6.5 x 18	4	–	119 29478	119 39478	–
	10	8 x 18	5	–	119 29109	119 39109	–
	15	10 x 18	6	–	119 29159	119 39159	–
	22	10 x 18	6	–	119 29229	119 39229	–
	47	10 x 25	7	–	119 90518	119 90519	–
	47	10 x 30	00	119 19479	119 29479	–	–
	68	12.5 x 30	01	119 19689	119 29689	–	–
	100	15 x 30	02	119 19101	119 29101	–	119 49101
	150	15 x 30	02	119 19151	119 29151	–	119 49151
	220	18 x 30	03	119 19221	–	–	119 49221
	330	18 x 40	04	119 19331	–	–	119 49331
	470	21 x 40	05	119 19471	–	–	119 49471
200	4.7	10 x 18	6	–	119 90507	119 90508	–
	10	10 x 25	7	–	119 90509	119 90511	–

Voltage

Surge voltage for short periods	$U_s \leq 1.15 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Note

For applications at ambient temperatures of ≤85 °C, the rated voltage (U_R) may be raised to U_{R2} in accordance with Table 6.

Table 6 Uprating values at reduced ambient temperature

U_R at T_{amb} 85 to 125 °C	10 V	16 V	25 V	40 V	63 V	100 V	200 V
U_{R2} at T_{amb} ≤85 °C	16 V	25 V	40 V	63 V	100 V	125 V	250 V

Leakage current

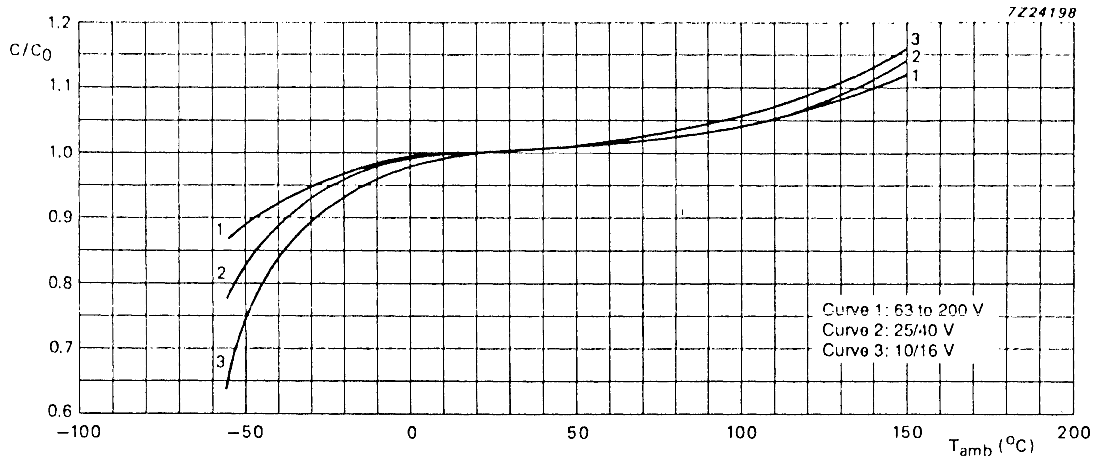
After 1 minute at U_R	
10 to 40 V	$I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$, or 10 µA (whichever is greater)
63 to 200 V	$I_{L1} \leq 0.006\ C_R \times U_R + 4\ \mu A$, or 20 µA (whichever is greater)
After 5 minutes at U_R	
10 to 63 V	$I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$
100 and 200 V	$I_{L5} \leq 0.002\ C_R \times U_R + 4\ \mu A$, or 10 µA (whichever is greater)

Marking

The capacitors are marked (where possible) with the following information:

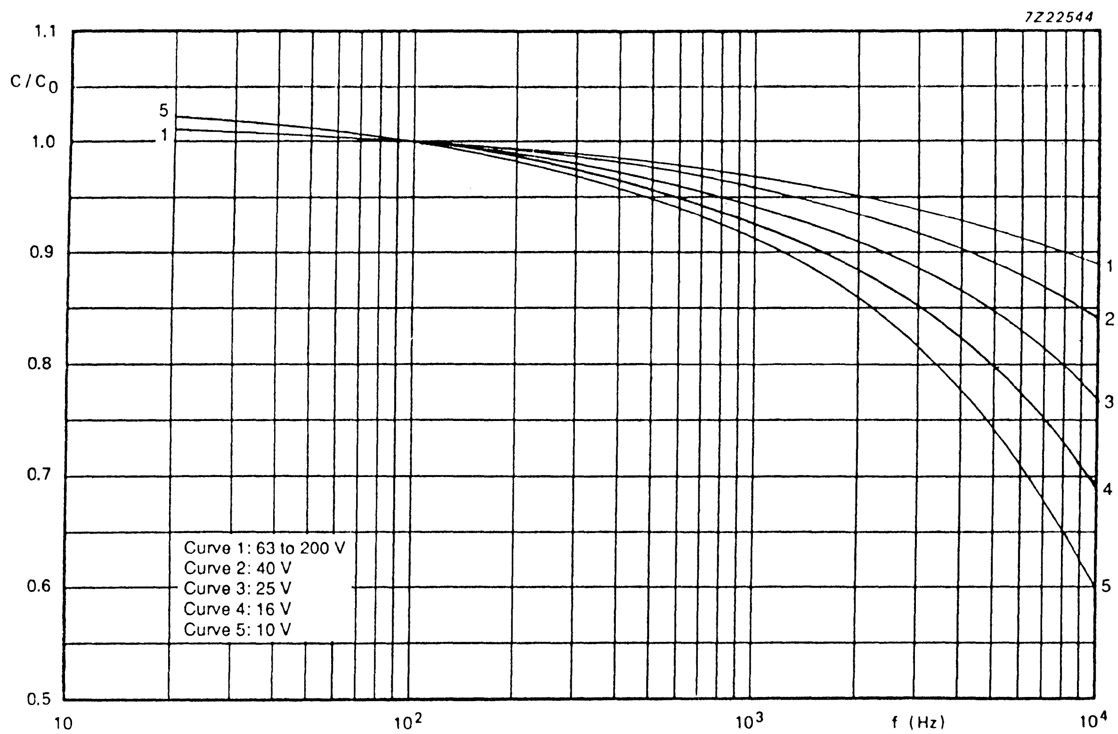
- Rated capacitance in µF
- Tolerance on rated capacitance, code letter in accordance with IEC 62
- Rated voltage in V (at 125 °C and at 85 °C)
- Group number (119)
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Code indicating factory of origin
- Band to identify the negative terminal
- "+" - signs to identify the positive terminal.

Capacitance (C)



C_0 = capacitance at 20 °C, 100 Hz.

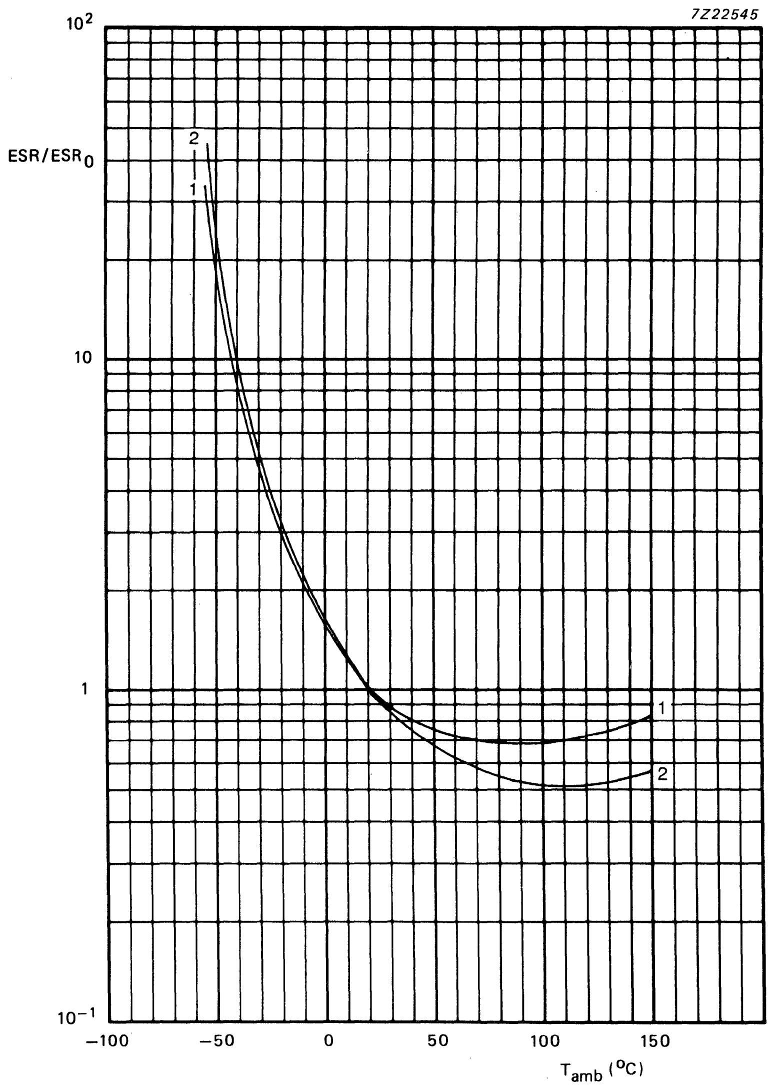
Fig.5 Multiplier of capacitance (C/C_0) as a function of ambient temperature.



C_0 = capacitance at 20 °C; 100 Hz.

Fig.6 Multiplier of capacitance (C/C_0) as a function of frequency.

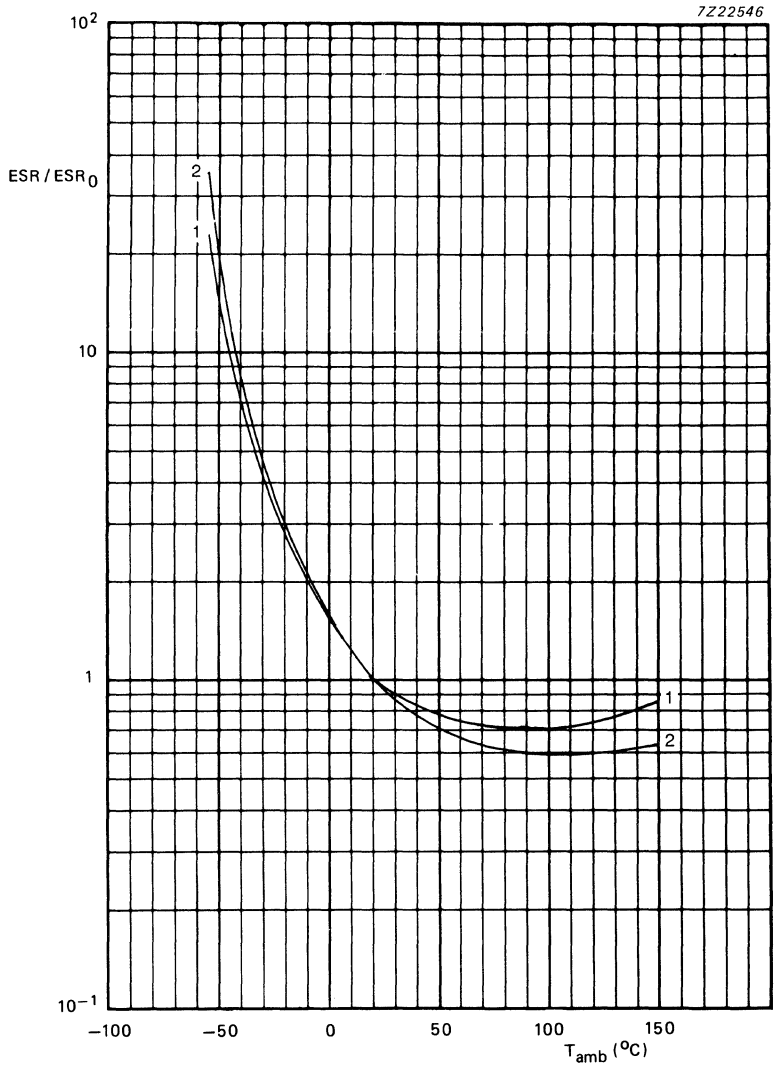
Equivalent series resistance (ESR)



Curve 1: 25 to 200 V
Curve 2: 10 and 16 V.

ESR_0 = typical ESR at 20 °C, 100 Hz.

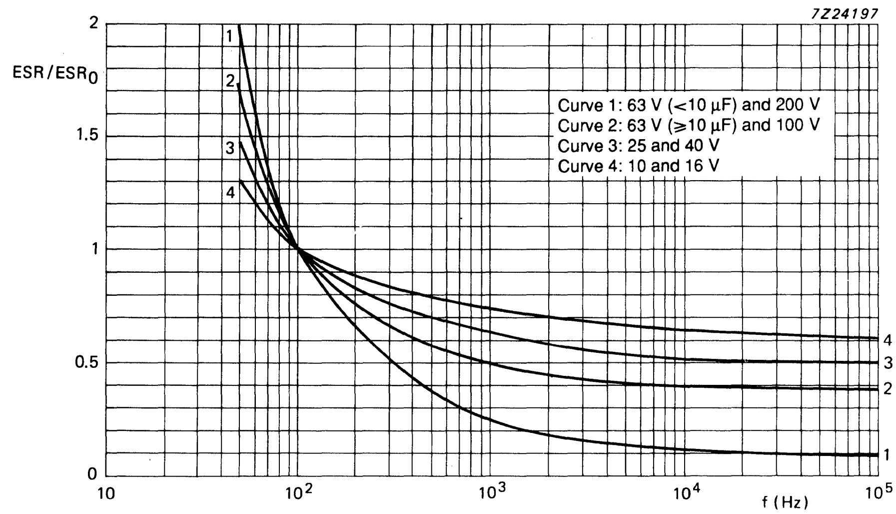
Fig.7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; case sizes 6.5 x 18 to 15 x 30 mm.



Curve 1: 25 to 100 V
Curve 2: 10 and 16 V.

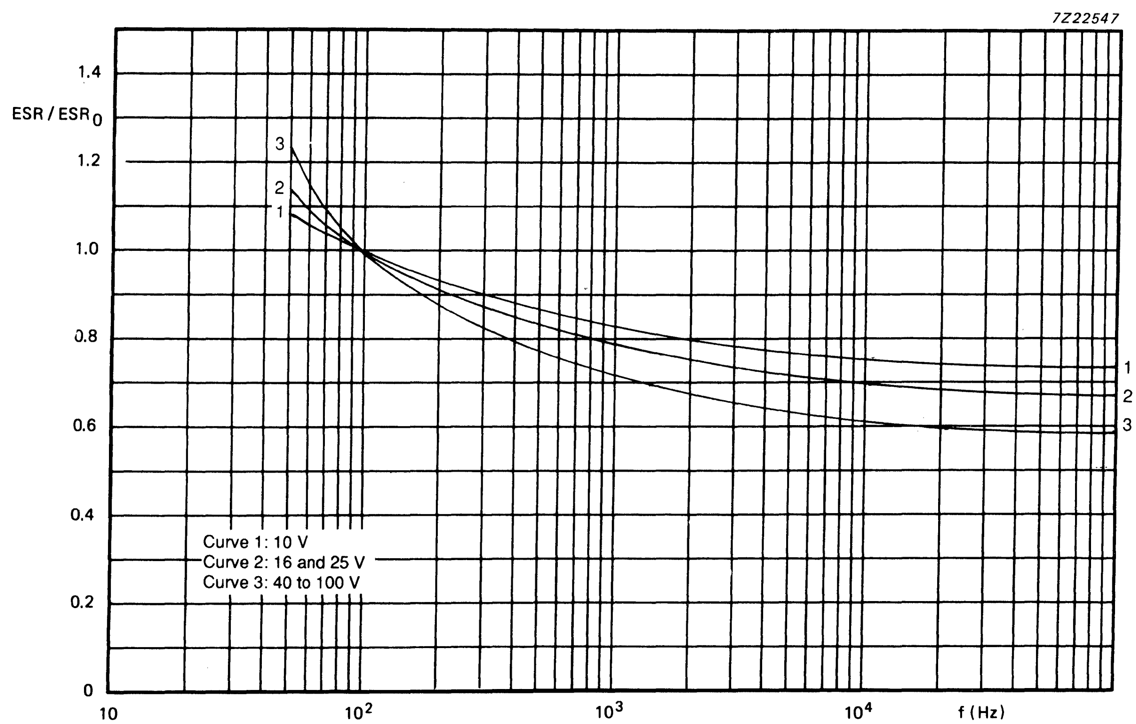
ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.8 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; case sizes 18 x 30 mm to 21 x 40 mm.



ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.9 Multiplier of ESR (ESR/ESR_0) as a function of frequency; case sizes 6.5 x 18 to 10 x 25 mm.



ESR_0 = typical ESR at 20 °C, 100 Hz.

Fig.10 Multiplier of ESR (ESR/ESR_0) as a function of frequency; case sizes 10 x 30 to 21 x 40 mm.

Equivalent series inductance (ESL)

Table 7 Equivalent series inductance, typical values

CASE SIZE ∅ x L (mm)	AXIAL (nH)	SINGLE ENDED (nH)
6.5 x 18	15	–
8 x 18	35	–
10 x 18	69	–
10 x 25	38	–
10 x 30	38	–
12.5 x 30	46	–
15 x 30	48	39
18 x 30	50	39
18 x 40	54	39
21 x 40	59	39

Impedance (Z)

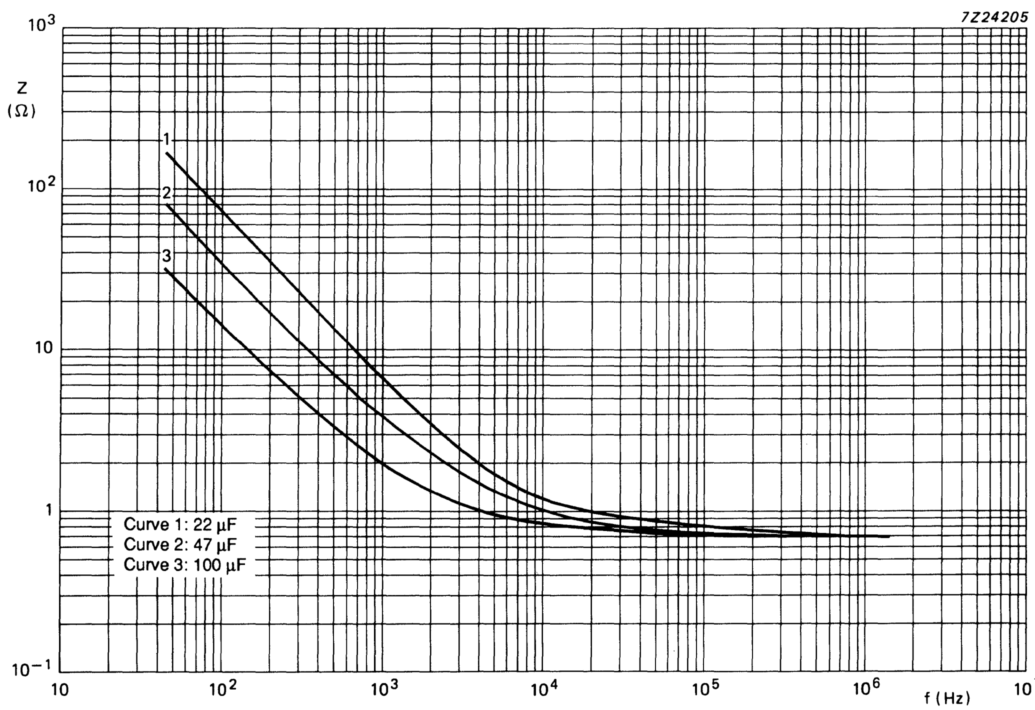


Fig.11 Typical impedance as a function of frequency at 20 °C; case size 8 x 18.

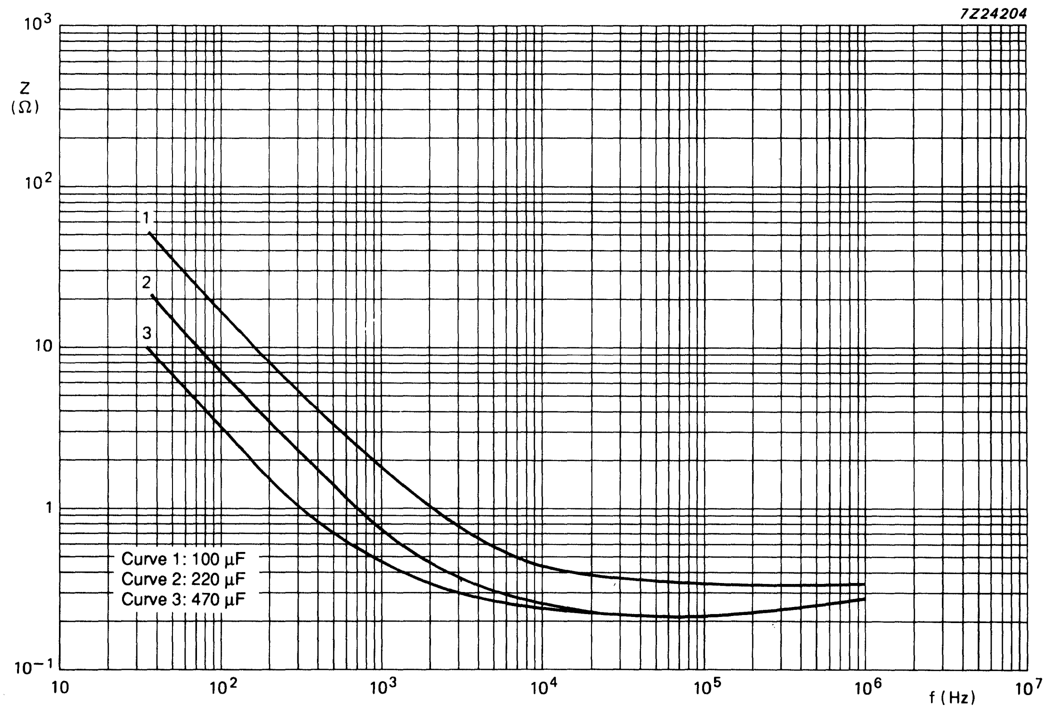


Fig.12 Typical impedance as a function of frequency at 20 °C; case size 10 x 25.

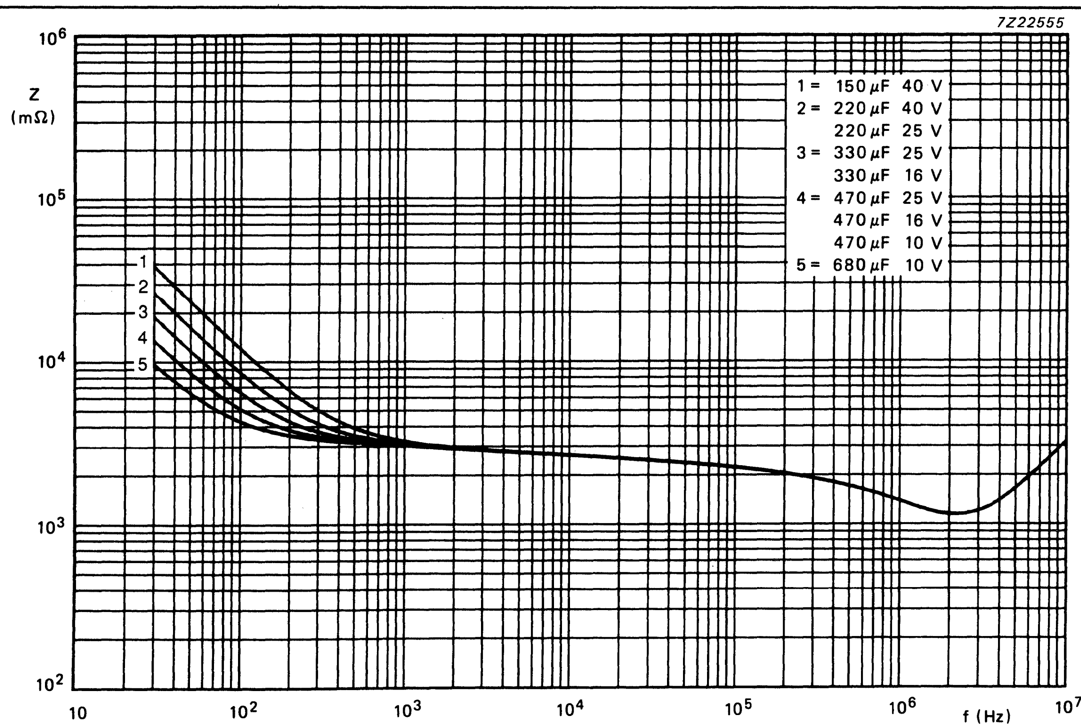


Fig.13 Typical impedance as a function of frequency at –40 °C; case size 12.5 x 30.

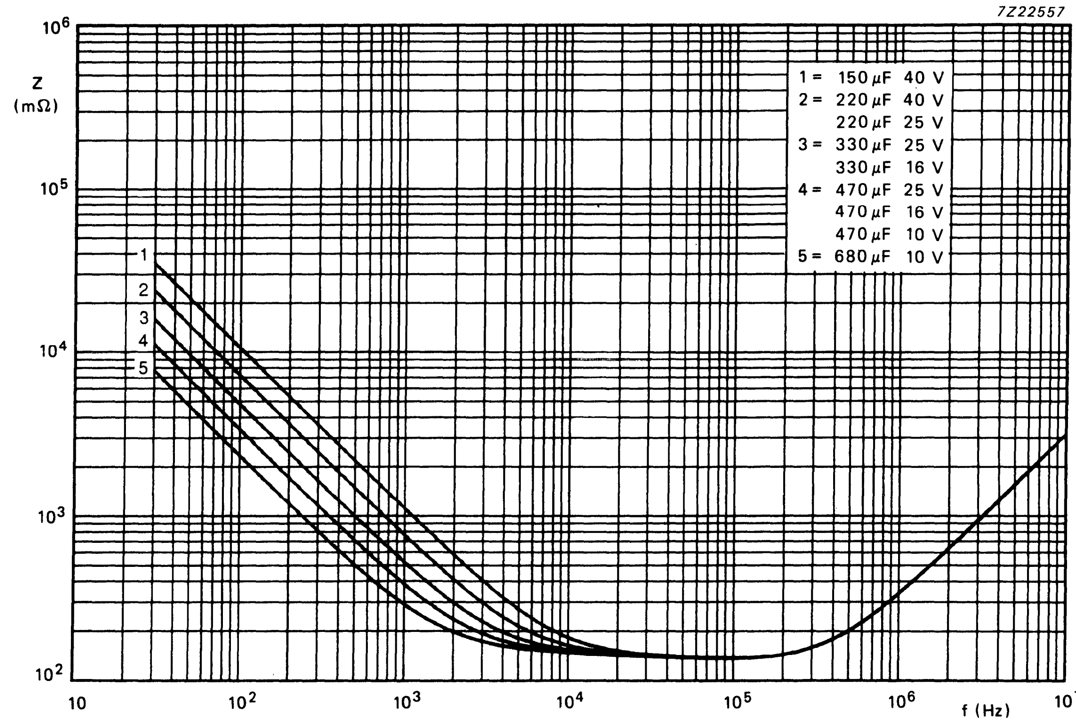


Fig.14 Typical impedance as a function of frequency at 20 °C; case size 12.5 x 30.

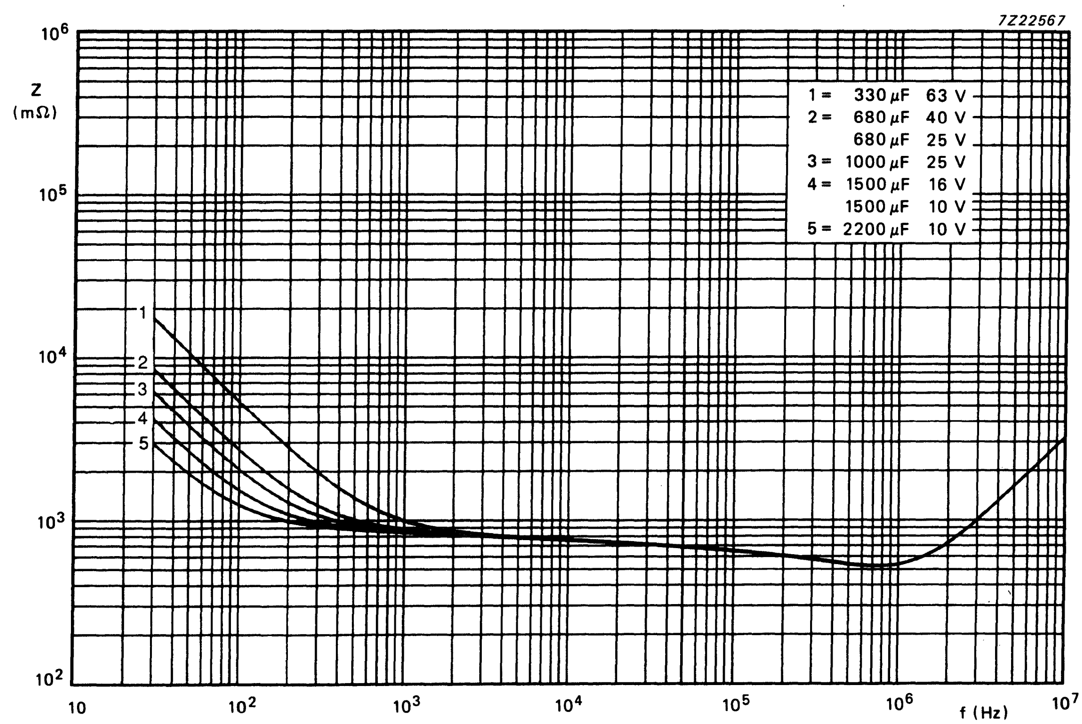


Fig.15 Typical impedance as a function of frequency at −40 °C; case size 18 x 30.

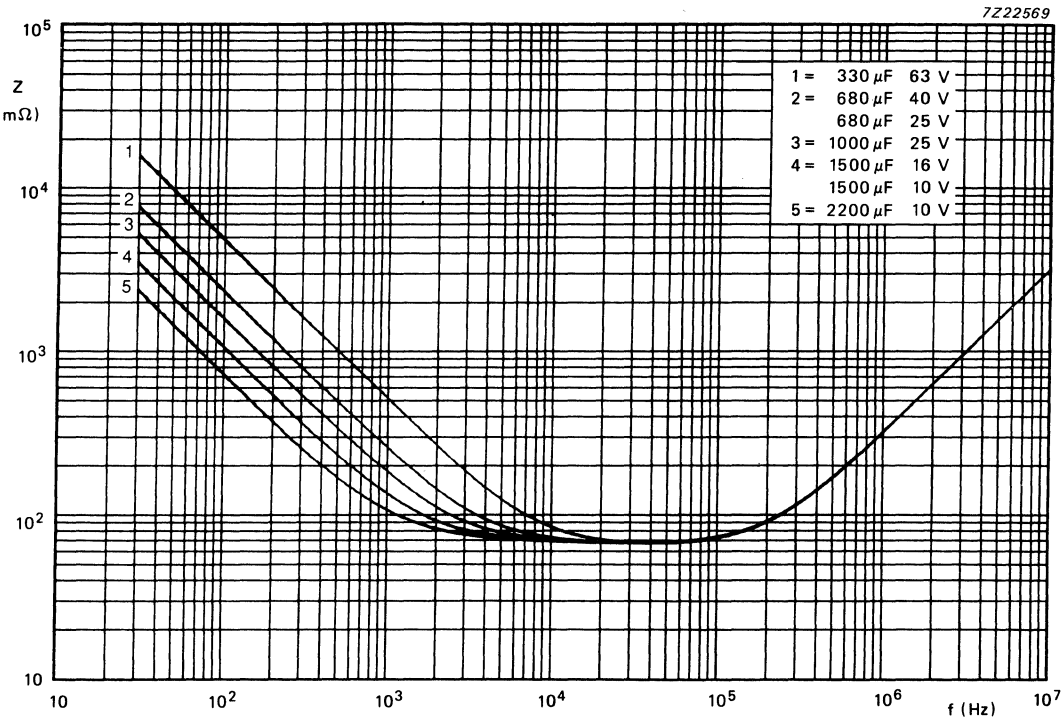
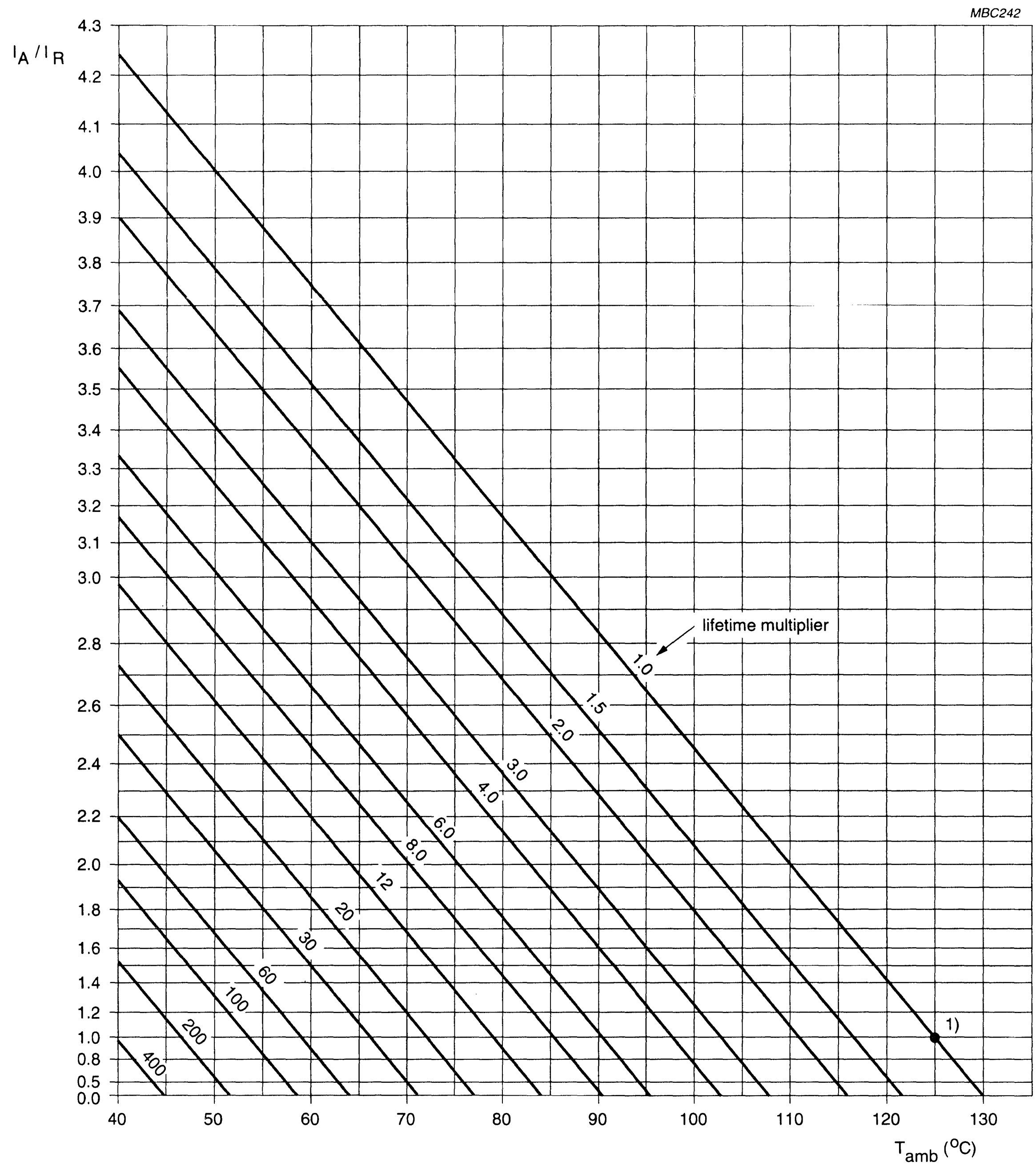


Fig.16 Typical impedance as a function of frequency at 20 °C; case size 18 x 30.

RIPPLE CURRENT and USEFUL LIFE

Table 8 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 125 °C, 100 Hz.

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 10 and 16 V	U_R = 25 and 40 V	U_R = 63 to 200 V
50	0.95	0.9	0.85
100	1.0	1.0	1.0
300	1.07	1.12	1.2
1000	1.12	1.2	1.3
3000	1.15	1.25	1.35
≥10 000	1.2	1.3	1.4



I_A = actual ripple current at 100 Hz.
I_R = rated ripple current at 100 Hz, 125 °C.

1) Useful life at 125 °C and I_R applied: 4000 hours.

Fig.17 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 9

<table>
<tr><th colspan="2">TEST</th><th rowspan="2">PROCEDURE
(quick reference)</th><th rowspan="2">REQUIREMENTS</th></tr>
<tr><th>Name of test</th><th>Reference</th></tr>
<tr><td>Endurance</td><td>IEC 384-4-1/
CECC 30 301
group C 3, 4.13</td><td>T_{amb} = 125 °C, U_R applied
case sizes:
6.5 x 18 to 10 x 25: 2000 hours
10 x 30 to 21 x 40: 4000 hours</td><td>ΔC/C ±15%
tan δ ≤1.3 x spec. limit
Z ≤2 x spec. limit
I_{L5} ≤spec. limit</td></tr>
<tr><td>Useful life</td><td>CECC 30 301
amendment 2640
sub clause 1.8.1</td><td>T_{amb} = 125 °C, U_R and I_R applied
4000 hours</td><td>ΔC/C ±45%
tan δ ≤3 x spec. limit
Z ≤3 x spec. limit
I_{L5} ≤spec. limit
no short or open circuit
total failure percentage: ≤1%</td></tr>
<tr><td>Shelf life
(Storage at
high temp.)</td><td>IEC 384-4-1/
CECC 30 301
group C 5a, 4.17</td><td>T_{amb} = 125 °C, no voltage applied
U_R 10 to 63 V: 500 hours
U_R 100 and 200 V: 100 hours

after test : U_R to be applied for
30 minutes, 24 to 48 hours
before measurement</td><td>ΔC/C, tan δ, Z: for requirements
see Endurance test above

I_{L5} ≤2 x spec. limit</td></tr>
<tr><td>Reverse
voltage</td><td>IEC 384-4-1/
CECC 30 301
sub clause 4.15</td><td>T_{amb} = 125 °C:
125 hours at U = –1 V followed by
125 hours at U_R</td><td>ΔC/C ±20%
tan δ ≤spec. limit
I_{L5} ≤spec. limit</td></tr>
</table>

NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Axial leads, cylindrical aluminium case, insulated with a blue sleeve
- Mounting ring version (single ended) not insulated
- Case sizes 10 x 30 to 21 x 40 with safety vent
- Taped versions up to 15 x 30 available for automatic insertion
- Charge and discharge proof
- Long useful life: 10 000/15 000 hours at 85 °C, high reliability
- High ripple current capability.
- Boards with restricted mounting height, vibration and shock resistant.

APPLICATIONS

- General industrial, telecommunication, EDP, power supplies
- Coupling, decoupling, timing; smoothing, filtering and buffering in SMPS

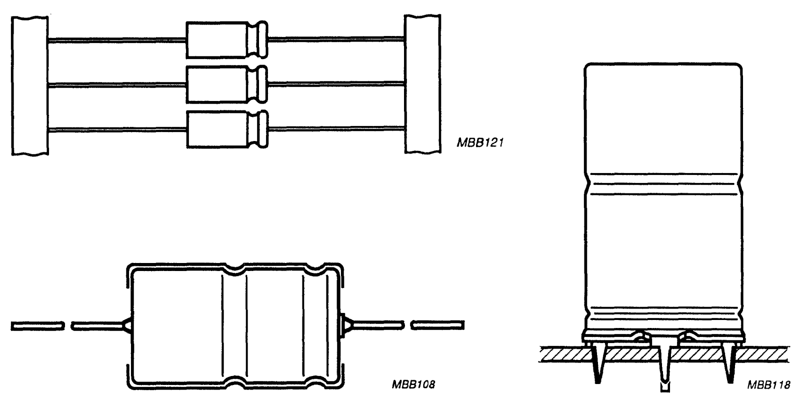


Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (Ø D_{nom} x L_{nom} in mm)	6.5 x 18 and 8 x 18	10 x 18 and 10 x 25	10 x 30 to 21 x 40
Rated capacitance range, C_R	1 to 4700 µF		
Tolerance on C_R	−10 to +50%		
Rated voltage range, U_R	10 to 400 V		
Category temperature range	−40 to +85 °C		
Endurance test at 105 °C	2000 hours	2000 hours	–
Endurance test at 85 °C	6000 hours	8000 hours	8000 hours
Useful life at 105 °C	3000 hours	3000 hours	–
Useful life at 85 °C	10 000 hours	15 000 hours	15 000 hours
Useful life at 40 °C, 1.8 I_R applied	160 000 hours	240 000 hours	240 000 hours
Shelf life at 0 V, 85 °C	500 hours		
Basic specification	IEC 384-4/CECC 30 300, LL grade		
Detail specification	DIN 45910 - T 123 (DIN 41257)		
Climatic category IEC 68 DIN 40040	40/085/56 GPF		
Approvals	CECC 30 301-056		CECC 30 301-801 UTE CO31/CO33

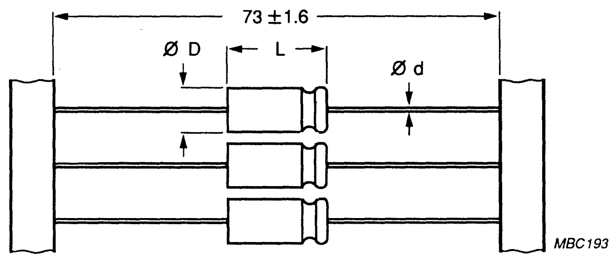
Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

Table 1 Selection chart for $C_R U_R$ and relevant nominal case sizes (∅ **D x L** in **mm**) ∗ = preferred values

C_R (μF)	U_R (V)									
	10	**16**	**25**	**40**	**63**	**100**	**160**	**250**	**350**	**385 400**
1.0∗						6.5 x 18			6.5 x 18	
2.2∗						6.5 x 18	6.5 x 18	8 x 18	8 x 18	
4.7∗					6.5 x 18	6.5 x 18	8 x 18	10 x 18	10 x 18	
6.8					6.5 x 18	8 x 18	10 x 18	10 x 25		10 x 30
10∗					6.5 x 18	8 x 18	10 x 18	10 x 25	12.5 x 30	12.5 x 30
15				6.5 x 18	8 x 18	10 x 18	10 x 25			15 x 30
22∗			6.5 x 18		8 x 18	10 x 18	10 x 25 10 x 30	12.5 x 30	15 x 30	18 x 30
33			6.5 x 18	8 x 18	10 x 18	10 x 25				18 x 40
47∗		6.5 x 18		8 x 18	10 x 18	10 x 25 10 x 30	15 x 30	18 x 30	18 x 40	18 x 40
68		6.5 x 18	8 x 18	10 x 18	10 x 25 10 x 30	12.5 x 30				21 x 40
100∗		8 x 18		10 x 18	10 x 30	15 x 30	18 x 30	21 x 40		
150		8 x 18	10 x 18	10 x 25 12.5 x 30	15 x 30	18 x 30				
220∗	8 x 18	10 x 18	10 x 25 12.5 x 30	12.5 x 30	15 x 30	18 x 40	21 x 40			
330		10 x 25 12.5 x 30	12.5 x 30	15 x 30	18 x 30	18 x 40				
470∗	12.5 x 30	10 x 25 12.5 x 30	12.5 x 30	15 x 30	18 x 40	21 x 40				
680	12.5 x 30	15 x 30	18 x 30	18 x 30	21 x 40					
1000∗	15 x 30	15 x 30	18 x 30	18 x 40	21 x 40					
1500∗	18 x 30	18 x 30	18 x 40	21 x 40						
2200∗	18 x 30	18 x 40	21 x 40	21 x 40						
3300∗	18 x 40	21 x 40								
4700∗	21 x 40	21 x 40								

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

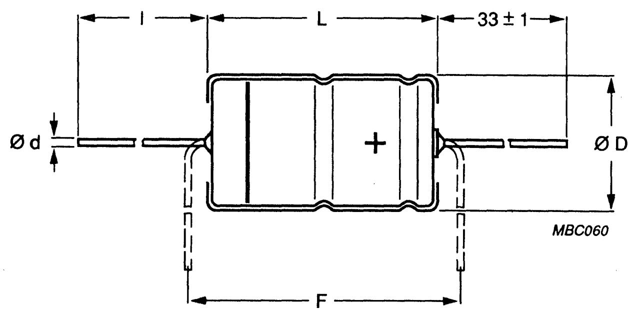
Dimensions in mm.
Tape dimensions are specified in chapter "PACKING".



Form BR: Taped on reel, case sizes 6.5 x 18 to 15 x 30.

Form BA: Taped in box (ammopack), case sizes 6.5 x 18 to 10 x 25.

Fig.2 Case sizes 6.5 x 18 to 15 x 30.



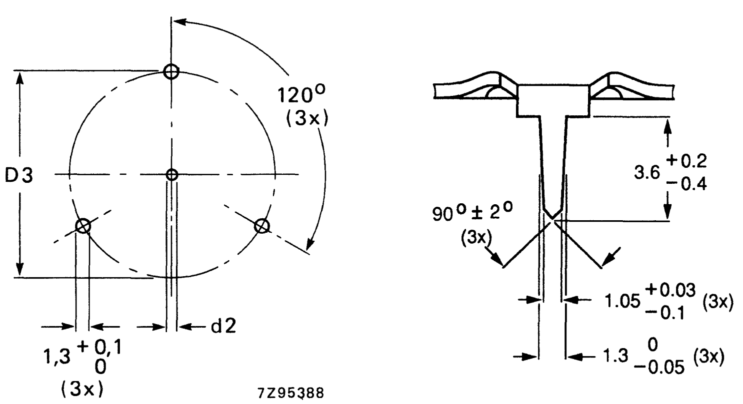
Form AA: Axial in box.

For case sizes 18 x 40 and 21 x 40, the stated L may be exceeded by 0.7 mm.

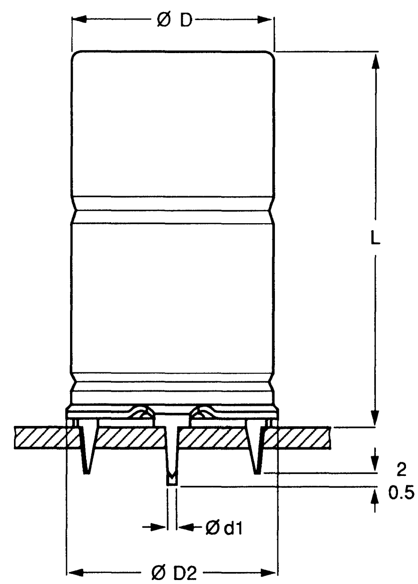
Fig.3 Case sizes 10 x 30 to 21 x 40.

Table 2 Axial, dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	AXIAL: Form AA, BA, and BR					APPROX. MASS	PACKING QUANTITIES		
		Ød	l	ØD_{max}	L_{max}	F_{min}		Form AA	Form BA	Form BR
6.5 x 18	4	0.8	–	6.9	18.5	25	1.3	–	1000	1000
8 x 18	5	0.8	–	8.5	18.5	25	1.7	–	500	500
10 x 18	6	0.8	–	10.5	18.5	25	2.5	–	500	500
10 x 25	7	0.8	–	10.5	25.0	30	3.3	–	500	500
10 x 30	00	0.8	55 ±1	10.5	30.5	35	4.8	200	–	500
12.5 x 30	01	0.8	55 ±1	13.0	30.5	35	7.4	200	–	400
15 x 30	02	0.8	55 ±1	15.5	30.5	35	11.7	200	–	250
18 x 30	03	0.8	55 ±1	18.5	30.5	35	12.9	200	–	–
18 x 40	04	0.8	34 ±1	18.5	41.5	45	19.4	100	–	–
21 x 40	05	0.8	34 ±1	21.5	41.5	45	24.7	100	–	–



Piercing diagram.



Form MR: case not insulated (insulation on request).
Especially for applications with severe shocks and vibrations.

Fig.4 Case sizes 15 x 30 to 21 x 40, single ended with mounting ring and pins.

Table 3 Single ended, dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	SINGLE ENDED WITH MOUNTING RING: Form MR						APPROX. MASS	PACKING QUANTITIES
		Ød_1	Ød_2	ØD_{max}	ØD2$_{max}$	D3	L_{max}		
15 x 30	02	0.8	1.0 +0.1	15.5	17.5	16.5 ±0.2	33	11.7	200
18 x 30	03	0.8	1.0 +0.1	18.5	19.5	18.5 ±0.2	33	12.9	200
18 x 40	04	1.0	1.3 +0.1	18.5	19.5	18.5 ±0.2	45	19.4	100
21 x 40	05	1.0	1.3 +0.1	21.5	22.5	21.5 ±0.2	45	24.7	100

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 4 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz, tolerance −10 to +50%
I_R	= rated RMS ripple current at 100 Hz, 85 °C
I_{L1}	= max. leakage current after 1 minute at U_R
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	= max. impedance at 10 kHz or 100 kHz

Table 4 Electrical data

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)
10	220	8 x 18	190	25	8.4	0.18	1.3	0.73	0.70
	470	12.5 x 30	350	32	9.4	0.18	0.77	0.26	0.60
	680	12.5 x 30	460	45	13.6	0.18	0.53	0.20	0.40
	1000	15 x 30	640	64	20	0.18	0.36	0.12	–
	1500	18 x 30	800	94	30	0.22	0.29	0.10	–
	2200	18 x 30	1100	140	44	0.22	0.20	0.09	–
	3300	18 x 40	1300	200	66	0.27	0.16	0.05	–
	4700	21 x 40	1800	290	94	0.27	0.12	0.05	–
16	47	6.5 x 18	95	11	5.5	0.14	4.7	2.6	2.2
	68	6.5 x 18	110	14	6.2	0.14	3.3	1.8	1.6
	100	8 x 18	150	19	7.2	0.14	2.2	1.2	1.1
	150	8 x 18	190	27	8.8	0.14	1.5	0.80	0.80
	220	10 x 18	250	38	11	0.14	1.0	0.55	0.55
	330	10 x 25	320	56	14.6	0.14	0.67	0.36	0.36
	330	12.5 x 30	320	36	10.6	0.14	0.80	0.36	0.60
	470	10 x 25	450	78	19	0.14	0.55	0.26	0.26
	470	12.5 x 30	450	49	15	0.14	0.55	0.26	0.40
	680	15 x 30	550	69	22	0.14	0.39	0.14	–
	1000	15 x 30	780	100	32	0.14	0.26	0.12	–
	1500	18 x 30	950	150	48	0.15	0.19	0.10	–
	2200	18 x 40	1300	220	70	0.15	0.12	0.06	–
	3300	21 x 40	1600	320	110	0.15	0.09	0.05	–
	4700	21 x 40	2300	460	150	0.15	0.08	0.05	–

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor ALL-DIN 2222 132/133 . . . . .
100 μF/40 V, −10/+50%
Case size 10 x 18; Form BR
Catalogue number: 2222 132 27101.

Table 5 Ordering information

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
10	220	8 x 18	5	–	132 24221	132 34221	–
	470	12.5 x 30	01	132 14471	132 24471	–	–
	680	12.5 x 30	01	132 14681	132 24681	–	–
	1000	15 x 30	02	132 14102	132 24102	–	132 44102
	1500	18 x 30	03	132 14152	–	–	132 44152
	2200	18 x 30	03	132 14222	–	–	132 44222
	3300	18 x 40	04	132 14332	–	–	132 44332
	4700	21 x 40	05	132 14472	–	–	132 44472
16	47	6.5 x 18	4	–	132 25479	132 35479	–
	68	6.5 x 18	4	–	132 25689	132 35689	–
	100	8 x 18	5	–	132 25101	132 35101	–
	150	8 x 18	5	–	132 25151	132 35151	–
	220	10 x 18	6	–	132 25221	132 35221	–
	330	10 x 25	7	–	132 90508	132 90509	–
	330	12.5 x 30	01	132 15331	132 25331	–	–
	470	10 x 25	7	–	132 90507	132 90502	–
	470	12.5 x 30	01	132 15471	132 25471	–	–
	680	15 x 30	02	132 15681	132 25681	–	132 45681
	1000	15 x 30	02	132 15102	132 25102	–	132 45102
	1500	18 x 30	03	132 15152	–	–	132 45152
	2200	18 x 40	04	132 15222	–	–	132 45222
	3300	21 x 40	05	132 15332	–	–	132 45332
	4700	21 x 40	05	132 15472	–	–	132 45472

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)
25	22	6.5 x 18	60	8.5	5.1	0.11	8.0	4.1	2.9
	33	6.5 x 18	80	11	5.7	0.11	5.3	2.7	2.3
	68	8 x 18	140	20	7.4	0.11	2.6	1.3	1.1
	150	10 x 18	230	41	11.5	0.11	1.2	0.60	0.60
	220	10 x 25	340	58	15	0.11	0.8	0.40	0.40
	220	12.5 x 30	340	37	11	0.11	1.0	0.40	0.60
	330	12.5 x 30	410	54	16.5	0.11	0.63	0.30	0.40
	470	12.5 x 30	560	75	24	0.11	0.47	0.20	–
	680	18 x 30	700	106	34	0.11	0.32	0.10	–
	1000	18 x 30	1000	150	50	0.11	0.22	0.10	–
	1500	18 x 40	1100	230	75	0.12	0.16	0.06	–
	2200	21 x 40	1850	330	110	0.13	0.12	0.05	–
40	15	6.5 x 18	60	9	5.2	0.09	9.5	5	3.2
	33	8 x 18	100	16	6.6	0.09	4.3	2.3	1.9
	47	8 x 18	120	22	7.8	0.09	3.0	1.6	1.4
	68	10 x 18	170	30	9.4	0.09	2.1	1.1	1.0
	100	10 x 18	210	43	12	0.09	1.4	0.75	0.75
	150	10 x 25	310	63	16	0.09	0.95	0.50	0.50
	150	12.5 x 30	310	40	12	0.09	1.27	0.50	0.60
	220	12.5 x 30	410	57	17.5	0.09	0.86	0.34	0.40
	330	15 x 30	550	83	26	0.09	0.58	0.20	–
	470	15 x 30	700	120	38	0.09	0.40	0.16	–
	680	18 x 30	900	170	54	0.09	0.28	0.10	–
	1000	18 x 40	1200	240	80	0.09	0.19	0.08	–
	1500	21 x 40	1500	360	120	0.10	0.14	0.06	–
	2200	21 x 40	1900	530	180	0.10	0.10	0.05	–

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
25	22	6.5 x 18	4	–	132 26229	132 36229	–
	33	6.5 x 18	4	–	132 26339	132 36339	–
	68	8 x 18	5	–	132 26689	132 36689	–
	150	10 x 18	6	–	132 26151	132 36151	–
	220	10 x 25	7	–	132 90503	132 90504	–
	220	12.5 x 30	01	132 16221	132 26221	–	–
	330	12.5 x 30	01	132 16331	132 26331	–	–
	470	12.5 x 30	01	132 16471	132 26471	–	–
	680	18 x 30	03	132 16681	–	–	132 46681
	1000	18 x 30	03	132 16102	–	–	132 46102
	1500	18 x 40	04	132 16152	–	–	132 46152
	2200	21 x 40	05	132 16222	–	–	132 46222
40	15	6.5 x 18	4	–	132 27159	132 37159	–
	33	8 x 18	5	–	132 27339	132 37339	–
	47	8 x 18	5	–	132 27479	132 37479	–
	68	10 x 18	6	–	132 27689	132 37689	–
	100	10 x 18	6	–	132 27101	132 37101	–
	150	10 x 25	7	–	132 90511	132 90512	–
	150	12.5 x 30	01	132 17151	132 27151	–	–
	220	12.5 x 30	01	132 17221	132 27221	–	–
	330	15 x 30	02	132 17331	132 27331	–	132 47331
	470	15 x 30	02	132 17471	132 27471	–	132 47471
	680	18 x 30	03	132 17681	–	–	132 47681
	1000	18 x 40	04	132 17102	–	–	132 47102
	1500	21 x 40	05	132 17152	–	–	132 47152
	2200	21 x 40	05	132 17222	–	–	132 47222

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)
63	4.7	6.5 x 18	38	6.0	4.6	0.07	24	12	5
	6.8	6.5 x 18	45	7.3	4.9	0.07	16	8.1	4
	10	6.5 x 18	64	9.3	5.3	0.07	11	5.5	3.3
	15	8 x 18	80	12	5.9	0.07	7.4	3.7	2.5
	22	8 x 18	100	17	6.8	0.07	5.1	2.5	2.1
	33	10 x 18	140	24	8.2	0.07	3.4	1.7	1.5
	47	10 x 18	170	33	9.9	0.07	2.4	1.2	1.2
	68	10 x 25	210	46	12.6	0.07	1.6	0.81	0.60
	68	10 x 30	210	30	8.6	0.07	1.9	0.80	0.60
	100	10 x 30	300	42	12.6	0.07	1.3	0.60	0.40
	150	15 x 30	350	61	19	0.07	0.87	0.37	–
	220	15 x 30	520	87	28	0.07	0.58	0.25	–
	330	18 x 30	600	130	42	0.07	0.40	0.15	–
	470	18 x 40	970	180	59	0.07	0.27	0.12	–
	680	21 x 40	1000	260	86	0.07	0.19	0.08	–
	1000	21 x 40	1600	380	130	0.07	0.13	0.06	–
100	1	6.5 x 18	20	4.0	4.0	0.06	95	45	6
	2.2	6.5 x 18	30	5.2	4.4	0.06	43	20	5
	4.7	6.5 x 18	48	7.7	4.9	0.06	20	9.6	4
	6.8	8 x 18	60	9.8	5.4	0.06	14	6.6	3.5
	10	8 x 18	73	13	6	0.06	9.5	4.5	2.8
	15	10 x 18	100	18	7	0.06	6.4	3	1.8
	22	10 x 18	130	25	8.4	0.06	4.3	2	1.3
	33	10 x 25	170	36	10.6	0.06	2.9	1.4	1.1
	47	10 x 25	220	50	13.4	0.06	2.0	1	0.90
	47	10 x 30	220	32	9.4	0.06	2.4	1	0.90
	68	12.5 x 30	250	45	13.5	0.06	1.7	0.80	–
	100	15 x 30	380	64	20	0.06	1.1	0.50	–
	150	18 x 30	400	94	30	0.06	0.75	0.35	–
	220	18 x 40	660	140	44	0.06	0.5	0.20	–
	330	18 x 40	700	200	66	0.06	0.34	0.15	–
	470	21 x 40	1200	290	94	0.06	0.24	0.10	–

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222			
				AXIAL			SINGLE ENDED
				IN BOX Form AA	TAPED ON REEL Form BR	TAPED IN BOX Form BA	MOUNTING RING Form MR
63	4.7	6.5 x 18	4	–	132 28478	132 38478	–
	6.8	6.5 x 18	4	–	132 28688	132 38688	–
	10	6.5 x 18	4	–	132 28109	132 38109	–
	15	8 x 18	5	–	132 28159	132 38159	–
	22	8 x 18	5	–	132 28229	132 38229	–
	33	10 x 18	6	–	132 28339	132 38339	–
	47	10 x 18	6	–	132 28479	132 38479	–
	68	10 x 25	6	–	132 90513	132 90514	–
	68	10 x 30	00	132 18689	132 28689	–	–
	100	10 x 30	00	132 18101	132 28101	–	–
	150	15 x 30	02	132 18151	132 28151	–	132 48151
	220	15 x 30	02	132 18221	132 28221	–	132 48221
	330	18 x 30	03	132 18331	–	–	132 48331
	470	18 x 40	04	132 18471	–	–	132 48471
	680	21 x 40	05	132 18681	–	–	132 48681
	1000	21 x 40	05	132 18102	–	–	132 48102
100	1	6.5 x 18	4	–	132 29108	132 39108	–
	2.2	6.5 x 18	4	–	132 29228	132 39228	–
	4.7	6.5 x 18	4	–	132 29478	132 39478	–
	6.8	8 x 18	5	–	132 29688	132 39688	–
	10	8 x 18	5	–	132 29109	132 39109	–
	15	10 x 18	6	–	132 29159	132 39159	–
	22	10 x 18	6	–	132 29229	132 39229	–
	33	10 x 25	7	–	132 29339	132 39339	–
	47	10 x 25	7	–	132 90505	132 90506	–
	47	10 x 30	00	132 19479	132 29479	–	–
	68	12.5 x 30	01	132 19689	132 29689	–	–
	100	15 x 30	02	132 19101	132 29101	–	132 49101
	150	18 x 30	03	132 19151	–	–	132 49151
	220	18 x 40	04	132 19221	–	–	132 49221
	330	18 x 40	04	132 19331	–	–	132 49331
	470	21 x 40	05	132 19471	–	–	132 49471

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)
160	2.2	6.5 x 18	22	50	20	0.10	72	55	30
	4.7	8 x 18	37	50	20	0.10	34	26	20
	6.8	10 x 18	50	50	20	0.10	23	18	16
	10	10 x 18	61	50	20	0.10	16	12	10
	15	10 x 25	85	50	20	0.10	11	8	6
	22	10 x 25	120	50	20	0.10	7.2	5.5	2.5
	22	10 x 30	120	25	7	0.10	6.8	5.5	2.5
	47	15 x 30	180	50	15	0.10	3.2	2.6	–
	100	18 x 30	350	100	32	0.10	1.5	1.2	–
	220	21 x 40	610	220	70	0.10	0.7	0.60	–
250	2.2	8 x 18	25	50	20	0.10	72	50	30
	4.7	10 x 18	37	50	20	0.10	34	23	16
	6.8	10 x 25	55	50	20	0.10	23	16	12
	10	10 x 25	66	50	20	0.10	16	11	9
	22	12.5 x 30	130	37	11	0.10	6.8	5	–
	47	18 x 30	200	75	24	0.10	3.2	2.3	–
	100	21 x 40	370	150	50	0.10	1.5	1.1	–
350	1	6.5 x 18	15	50	20	0.10	160	100	40
	2.2	8 x 18	25	50	20	0.10	72	45	28
	4.7	10 x 18	43	50	20	0.10	34	21	15
	10	12.5 x 30	90	25	7	0.10	15	10	–
	22	15 x 30	140	50	15.5	0.10	6.8	4.5	–
	47	18 x 40	270	100	33	0.10	3.2	2.1	–
385	6.8	10 x 30	60	20	10	0.10	22	14	13.6
	10	12.5 x 30	90	27	12	0.10	15	10	8.5
	15	15 x 30	110	39	16	0.10	10	6	5.7
	22	18 x 30	147	55	21	0.10	6.8	4.1	3.9
	33	18 x 40	203	80	30	0.10	4.5	2.7	2.6
	47	18 x 40	242	110	41	0.10	3.2	2.1	2.0
	68	21 x 40	317	160	57	0.10	2.2	1.4	1.4

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
160	2.2	6.5 x 18	4	–	133 21228	133 31228	–
	4.7	8 x 18	5	–	133 21478	133 31478	–
	6.8	10 x 18	6	–	133 21688	133 31688	–
	10	10 x 18	6	–	133 21109	133 31109	–
	15	10 x 25	7	–	133 21159	133 31159	–
	22	10 x 25	7	–	133 90502	133 90503	–
	22	10 x 30	00	133 11229	133 21229	–	–
	47	15 x 30	02	133 11479	133 21479	–	133 41479
	100	18 x 30	03	133 11101	–	–	133 41101
	220	21 x 40	05	133 11221	–	–	133 41221
250	2.2	8 x 18	5	–	133 23228	133 33228	–
	4.7	10 x 18	6	–	133 23478	133 33478	–
	6.8	10 x 25	7	–	133 23688	133 33688	–
	10	10 x 25	7	–	133 23109	133 33109	–
	22	12.5 x 30	01	133 13229	133 23229	–	–
	47	18 x 30	03	133 13479	–	–	133 43479
	100	21 x 40	05	133 13101	–	–	133 43101
350	1	6.5 x 18	4	–	133 25108	133 35108	–
	2.2	8 x 18	5	–	133 25228	133 35228	–
	4.7	10 x 18	6	–	133 25478	133 35478	–
	10	12.5 x 30	01	133 15109	133 25109	–	–
	22	15 x 30	02	133 15229	133 25229	–	133 45229
	47	18 x 40	04	133 14479	–	–	133 44479
385	6.8	10 x 30	00	133 18688	133 28688	–	–
	10	12.5 x 30	01	133 18109	133 28109	–	–
	15	15 x 30	02	133 18159	133 28159	–	133 48159
	22	18 x 30	03	133 18229	–	–	133 48229
	33	18 x 40	04	133 18339	–	–	133 48339
	47	18 x 40	04	133 18479	–	–	133 48479
	68	21 x 40	05	133 18689	–	–	133 47689

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)	Z 100 kHz (Ω)
400	6.8	10 x 30	82	220	110	0.055	11.5	7.3	6.4
	10	12.5 x 30	128	240	110	0.055	7.5	4.6	4.0
	15	15 x 30	155	250	110	0.055	5.0	3.1	2.7
	22	18 x 30	206	280	120	0.055	3.5	2.1	1.8
	33	18 x 40	286	320	130	0.055	2.3	1.4	1.2
	47	18 x 40	333	370	140	0.055	1.7	1.1	0.9
	68	21 x 40	431	440	160	0.055	1.2	0.7	0.6

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . AXIAL IN BOX Form AA	AXIAL TAPED ON REEL Form BR	AXIAL TAPED IN BOX Form BA	SINGLE ENDED MOUNTING RING Form MR
400	6.8	10 x 30	00	133 16688	133 26688	–	–
	10	12.5 x 30	01	133 16109	133 26109	–	–
	15	15 x 30	02	133 16159	133 26159	–	133 46159
	22	18 x 30	03	133 16229	–	–	133 46229
	33	18 x 40	04	133 16339	–	–	133 46339
	47	18 x 40	04	133 16479	–	–	133 46479
	68	21 x 40	05	133 16689	–	–	133 46689

Voltage

Surge voltage for short periods
- 10 to 250 V types: $U_s \leq 1.15 \times U_R$
- 350 to 400 V types: $U_s \leq 1.1 \times U_R$

Reverse voltage: $U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R
- case sizes 6.5 x 18 to 10 x 25: 10 to 100 V types: $I_{L1} \leq 0.01\ C_R \times U_R + 3$ µA; 160 to 400 V types: $I_{L1} \leq 50$ µA
- case sizes 10 x 30 to 21 x 40: 10 to 385 V types: $I_{L1} \leq 0.006\ C_R \times U_R + 4$ µA; 400 V types: $I_{L1} \leq 0.009\ C_R \times U_R + 200$ µA

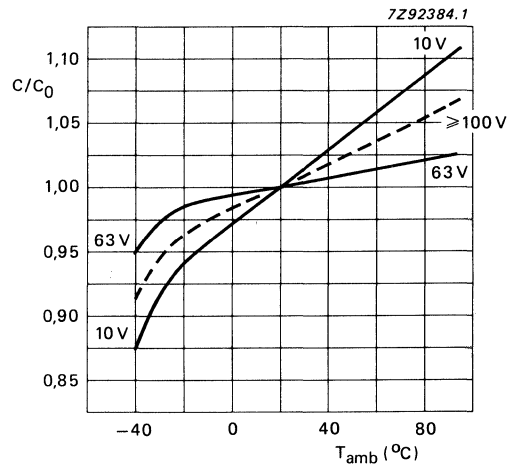
After 5 minutes at U_R
- case sizes 6.5 x 18 to 10 x 25: 10 to 100 V types: $I_{L5} \leq 0.002\ C_R \times U_R + 4$ µA; 160 to 400 V types: $I_{L5} \leq 20$ µA
- case sizes 10 x 30 to 21 x 40: 10 to 385 V types: $I_{L5} \leq 0.002\ C_R \times U_R$ µA; 400 V types: $I_{L5} \leq 0.002\ C_R \times U_R + 100$ µA

Marking

The capacitors are marked (where possible) with the following information:

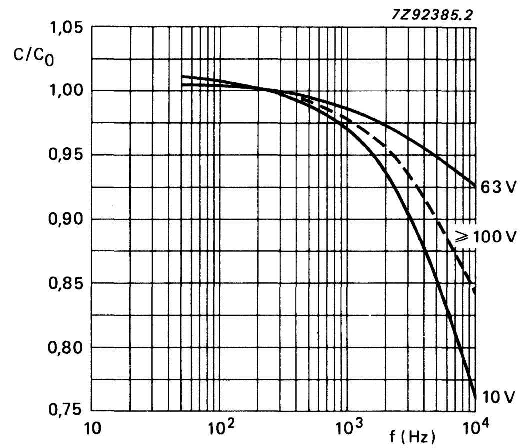
- Rated capacitance in µF
- Tolerance on rated capacitance, code letter in accordance with IEC 62
- Rated voltage in V
- Upper category temperature (85 °C)
- Group number (132 or 133)
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Code indicating factory of origin
- Band to identify the negative terminal
- "+" - signs to identify the positive terminal.

Capacitance (C)



C_0 = capacitance at 20 °C, 100 Hz.

Fig.5 Multiplier of capacitance (C/C_0) as a function of ambient temperature.



C_0 = capacitance at 20 °C, 100 Hz.

Fig.6 Multiplier of capacitance (C/C_0) as a function of frequency.

Equivalent series inductance (ESL)

Table 6 Equivalent series inductance, typical values

CASE SIZE (∅ x L) (mm)	AXIAL (nH)	SINGLE ENDED (nH)		CASE SIZE (∅ x L) (mm)	AXIAL (nH)	SINGLE ENDED (nH)
6.5 x 18	15	–		12.5 x 30	46	–
8 x 18	35	–		15 x 30	48	39
10 x 18	69	–		18 x 30	50	39
10 x 25	38	–		18 x 40	54	39
10 x 30	38	–		21 x 40	59	39

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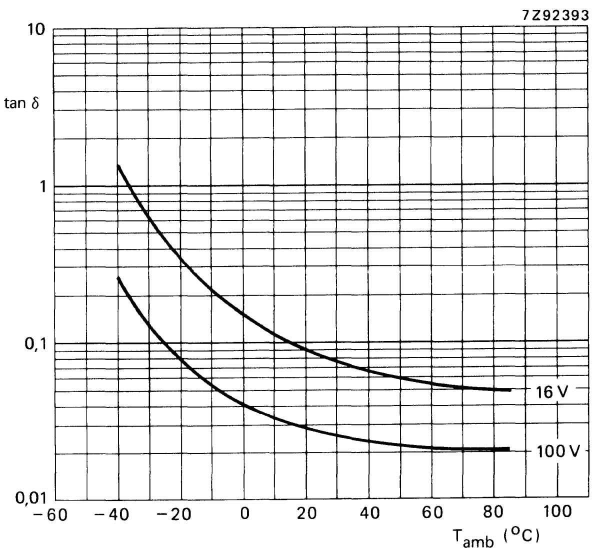
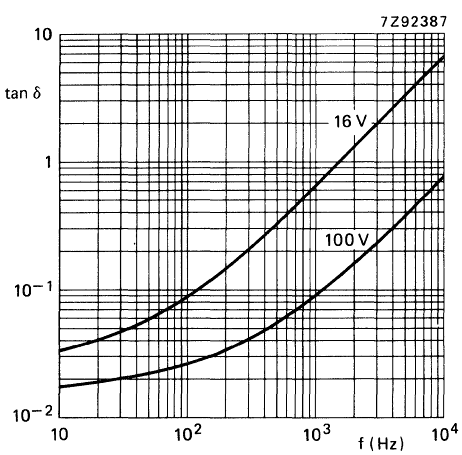
Dissipation factor (tan δ)



Frequency = 100 Hz.

Fig.7 Typical tan δ as a function of ambient temperature, case sizes 6.5 x 18 to 10 x 25.



Ambient temperature = 20 °C.

Fig.8 Typical tan δ as a function of frequency, case sizes 6.5 x 18 to 10 x 25.

Impedance (Z)

Curve 1: 4.7 μF - 100 V
Curve 2: 47 μF - 16 V
Curve 3: 150 μF - 16 V
Curve 4: 220 μF - 16 V
Curve 5: 470 μF - 16 V

Frequency = 10 kHz.

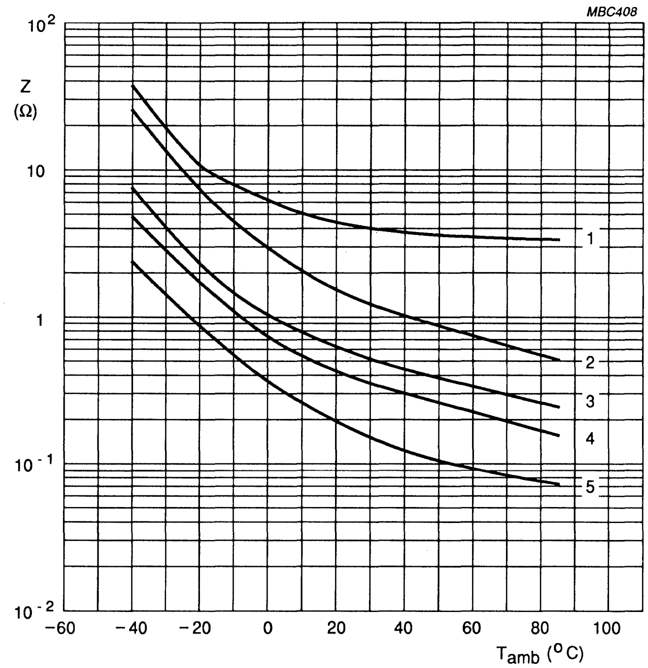


Fig.9 Typical impedance as a function of ambient temperature; case sizes 6.5 x 18 to 10 x 25.

Curve 1: 4.7 μF - 100 V
Curve 2: 47 μF - 16 V
Curve 3: 150 μF - 16 V
Curve 4: 220 μF - 16 V
Curve 5: 470 μF - 16 V

Ambient temperature = 20 °C.

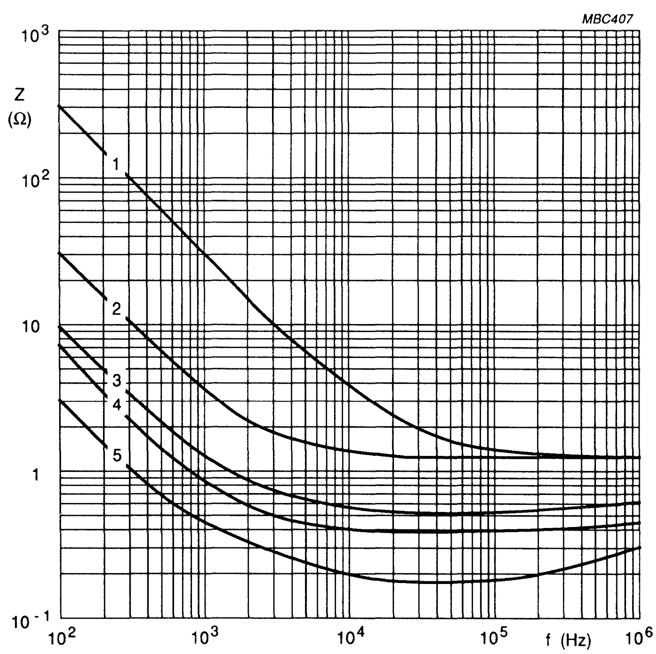
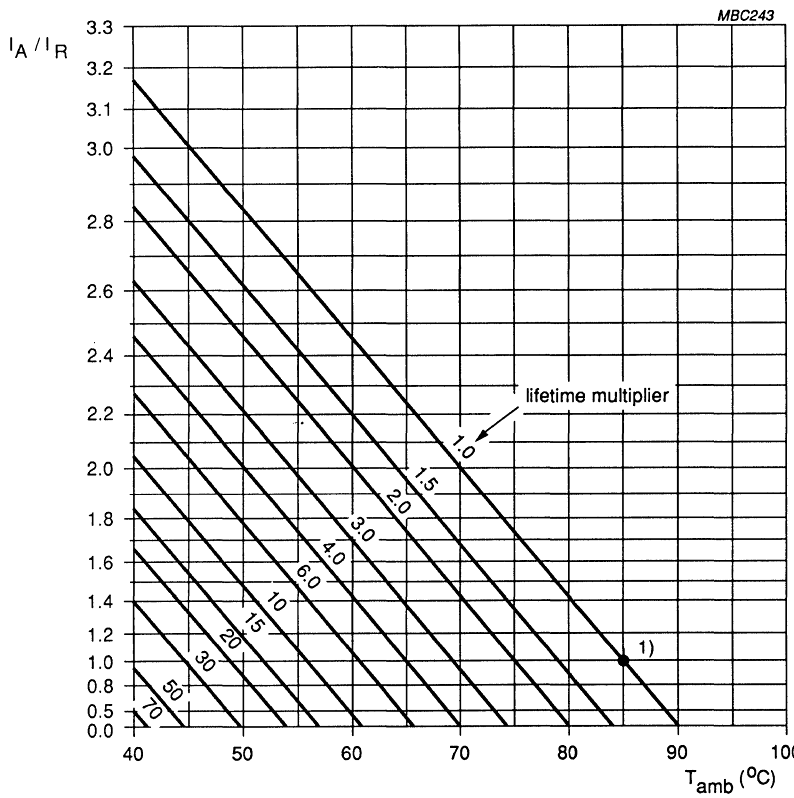


Fig.10 Typical impedance as a function of frequency; case sizes 6.5 x 18 to 10 x 25.

RIPPLE CURRENT and USEFUL LIFE

Table 7 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 85 °C, 100 Hz.

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 10 to 16 V	U_R = 25 to 63 V	U_R = 100 to 400 V
50	0.95	0.9	0.85
100	1.0	1.0	1.0
300	1.07	1.12	1.2
1000	1.12	1.2	1.3
3000	1.15	1.25	1.35
≥10 000	1.2	1.3	1.4



I_A = actual ripple current at 100 Hz.

I_R = rated ripple current at 100 Hz, 85 °C.

1) Useful life at 85 °C and I_R applied.
   case sizes 6.5 x 18 and 8 x 18: 10 000 hours
   case sizes 10 x 18 to 21 x 40: 15 000 hours.

Fig.11 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements".

Table 8

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 group C3, 4.13	T_{amb} = 85 °C, U_R applied case sizes: 6.5 x 18 and 8 x 18: 6000 hours 10 x 18 to 21 x 40: 8000 hours	U_R 10 to 160 V: ΔC/C ±15% U_R 250 to 400 V: ΔC/C ±10% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied case sizes: 6.5 x 18 and 8 x 18: 10 000 hours 10 x 18 to 21 x 40: 15 000 hours	U_R 10 to 160 V : ΔC/C ±45% U_R 250 to 400 V: ΔC/C ±30% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤1%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

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NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Radial leads, cylindrical aluminium case, insulated with a blue sleeve
- Charge and discharge proof
- Miniaturized, high CU-product per unit volume.

APPLICATIONS

- General purpose; industrial, automotive and audio-video
- Coupling, decoupling, timing; smoothing, filtering, buffering in SMPS
- Portable and mobile equipment (small size, low mass)
- Low surface demand on printed circuit board.

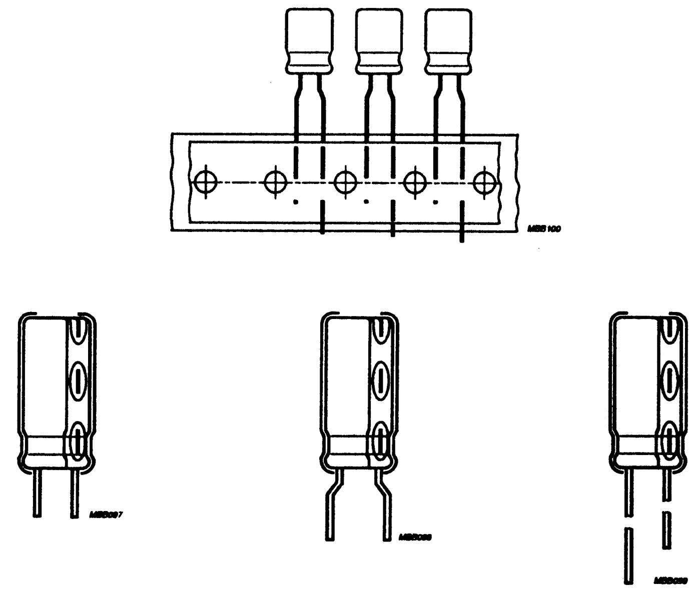

Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (∅ D_{nom} x L_{nom})	5 x 11 to 16 x 31 mm
Rated capacitance range, C_R	0.1 to 10 000 μF
Tolerance on C_R	±20% (±10% on request)
Rated voltage range, U_R	6.3 to 100 V
Category temperature range	–40 to +85 °C
Endurance test at 85 °C U_R = 6.3 to 16 V U_R = 25 to 100 V	 1000 hours 2000 hours
Useful life at 85 °C	2000 hours
Useful life at 40 °C, 1.4 I_R applied	60 000 hours
Shelf life at 0 V, 85 °C	500 hours
Basic specification	IEC 384-4/CECC 30300, GP grade
Detail specification	IEC 384-4-1/CECC 30301 similar to DIN 41259 (with reduced dimensions)
Climatic category IEC 68 DIN 40040	 40/085/56 GPF

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Table 1 Selection chart for C_RU_R and relevant nominal case sizes (**∅ D x L** in **mm**) ∗ = preferred values

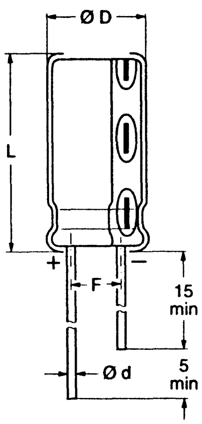
C_R (μF)	U_R (V)								
	6.3	**10**	**16**	**25**	**35**	**40**	**50**	**63**	**100**
0.10								5 x 11	
0.22 ∗								5 x 11	5 x 11
0.47 ∗								5 x 11	5 x 11
1.0 ∗								5 x 11	5 x 11
2.2 ∗								5 x 11	5 x 11
3.3								5 x 11	5 x 11
4.7 ∗								5 x 11	5 x 11
6.8								5 x 11	5 x 11
10 ∗							5 x 11	5 x 11	6.3 x 11
15						5 x 11		5 x 11	8 x 12
22 ∗					5 x 11	5 x 11	5 x 11	6.3 x 11	8 x 12
33			5 x 11		5 x 11	6.3 x 11	6.3 x 11	6.3 x 11	10 x 12
47 ∗		5 x 11		5 x 11		6.3 x 11	6.3 x 11	8 x 12	10 x 16
68	5 x 11		5 x 11	6.3 x 11		8 x 12	8 x 12	10 x 12	10 x 16
100 ∗		5 x 11	6.3 x 11	6.3 x 11		8 x 12	8 x 12	10 x 12	10 x 20
150	6.3 x 11	6.3 x 11	8 x 12	8 x 12		10 x 12		10 x 16	12.5 x 20
220 ∗	6.3 x 11	6.3 x 11	8 x 12	8 x 12	10 x 12		10 x 16	10 x 20	12.5 x 25
330	6.3 x 11	8 x 12	8 x 12	10 x 12	10 x 16	10 x 20	10 x 20	12.5 x 20	16 x 25
470 ∗	8 x 12	8 x 12	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 20	12.5 x 25	16 x 31
680		10 x 12	10 x 16		12.5 x 20	12.5 x 25	12.5 x 25	16 x 25	
1000 ∗	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 25	16 x 31	
1500	10 x 20		12.5 x 20	12.5 x 25	16 x 25	16 x 31			
2200 ∗	12.5 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31				
3300	12.5 x 20	12.5 x 25	16 x 25	16 x 31					
4700 ∗		16 x 25	16 x 31						
6800	16 x 25	16 x 31							
10 000 ∗	16 x 31								

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.

Table 2 Dimensions in mm; mass in g

CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	Ø d	ØD_{max}	L_{max}	F ±0.5	APPROX. MASS	PACKING QUANTITIES Form CA CB, CC	Form TR+ TR–, TN	Form TFA
5 x 11	11	0.5	5.5	12.5	2.0	0.4	3000	1500	2000
6.3 x 11	12	0.6	6.8	12.5	2.5	0.6	2000	1000	2000
8 x 12	13	0.6	8.5	13.0	3.5	1.1	1000	800	1000
10 x 12	14	0.6	10.5	13.5	5.0	1.6	1000	500	–
10 x 16	15	0.6	10.5	17.5	5.0	1.9	500	500	–
10 x 20	16	0.6	10.5	21.5	5.0	2.2	500	500	–
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0	200	200	–
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0	200	200	–
16 x 25	19	0.8	16.5	27.0	7.5	8.0	200	150	–
16 x 31	20	0.8	16.5	33.5	7.5	9.0	200	150	–



MRA220

Fig.2 **Form CA**: Long leads.

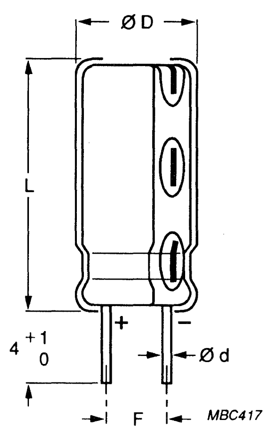


Fig.3 **Form CB**: Cut leads.

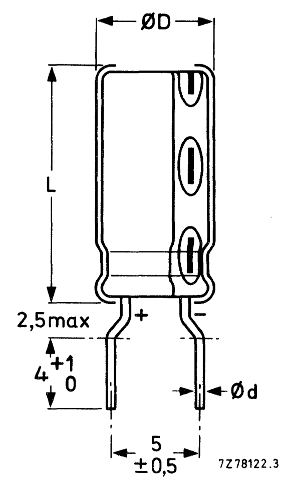
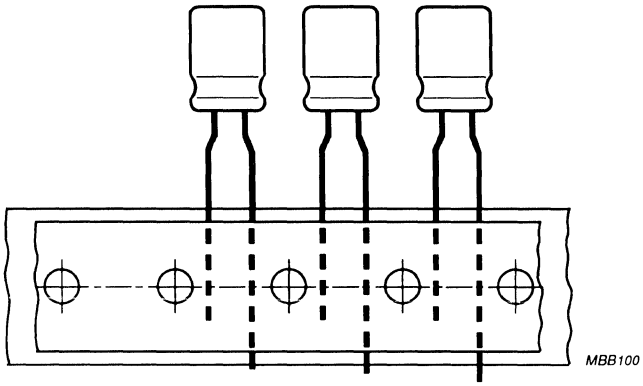


Fig.4 **Form CC**: Cut leads, formed; Ø D = 5, 6.3 and 8 mm only.

Taping dimensions are specified in chapter "PACKING",

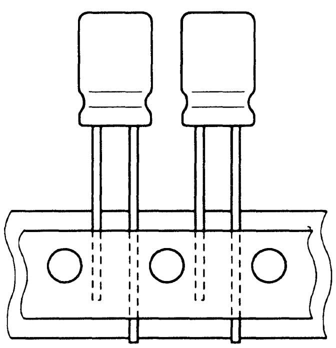


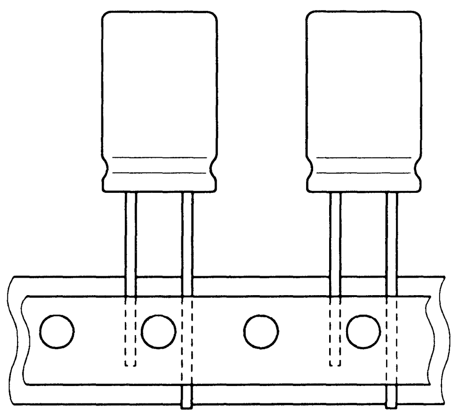
Form TR+: Taped on reel, positive leading.

Form TR–: Taped on reel, negative leading.

Form TFA : Taped in box (ammopack).

Fig.5 Taped, formed, pitch 5 mm; ∅D = 5 to 8 mm.





Form TN+:

∅D 5 mm: F = 2.5 mm
(leads slightly bent)

∅D 6.3 mm: F = 2.5 mm

∅D 8 mm: F = 3.5 mm

Form TR+:

∅D 10 and 12.5 mm: F = 5 mm

Form TR+:

∅D 16 mm: F = 7.5 mm

Fig.6 Taped on reel, straight leads, positive leading.

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 3 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	=	rated capacitance at 100 Hz, tolerance ± 20%
I_R	=	rated RMS ripple current at 100 Hz, 85 °C
I_{L1}	=	max. leakage current after 1 minute at U_R
I_{L5}	=	max. leakage current after 5 minutes at U_R
tan δ	=	max. dissipation factor at 100 Hz
ESR	=	equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	=	max. impedance at 10 kHz .

Table 3 Electrical data

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
6.3	68	5 x 11	11	80	7.3	3.9	0.24	7.0	8.8
	150	6.3 x 11	12	130	12	4.9	0.24	3.2	4.0
	220	6.3 x 11	12	170	17	5.8	0.24	2.2	2.7
	330	6.3 x 11	12	240	24	7.2	0.24	1.4	1.8
	470	8 x 12	13	300	33	8.9	0.24	1.0	1.3
	1000	10 x 12	14	510	66	16	0.24	0.48	0.6
	1500	10 x 20	16	670	98	22	0.25	0.33	0.4
	2200	12.5 x 20	17	890	140	31	0.26	0.24	0.27
	3300	12.5 x 20	17	1150	210	45	0.28	0.17	0.18
	6800	16 x 25	19	1550	430	89	0.35	0.10	0.09
	10 000	16 x 31	20	1750	630	130	0.42	0.08	0.07
10	47	5 x 11	11	75	7.7	3.9	0.20	8.5	9.6
	100	5 x 11	11	110	13	5	0.20	4.0	4.5
	150	6.3 x 11	12	140	18	6	0.20	2.7	3.0
	220	6.3 x 11	12	210	25	7.4	0.20	1.8	2.0
	330	8 x 12	13	270	36	9.6	0.20	1.2	1.4
	470	8 x 12	13	350	50	12	0.20	0.85	0.96
	680	10 x 12	14	420	71	17	0.20	0.59	0.66
	1000	10 x 16	15	630	100	23	0.20	0.40	0.45
	2200	12.5 x 20	17	1050	220	47	0.22	0.20	0.20
	3300	12.5 x 25	18	1250	330	69	0.24	0.14	0.14
	4700	16 x 25	19	1450	470	97	0.28	0.12	0.10
	6800	16 x 31	20	1700	680	140	0.32	0.09	0.07

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 037 . . . . .
1000 µF/16 V, ±20%
Case size 10 x 20 mm; Form CA
Catalogue number: 2222 037 55102.

Table 4 Ordering information

U_R (V)	C_R 100 Hz (µF)	CATALOGUE NUMBER 2222						
		BULK PACKING			TAPED ON REEL			TAPED IN BOX F = 5 mm
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR−	F = 2.5 mm or 3.5 mm positive leading Form TN+	Form TFA
6.3	68	037 53689	037 83689	037 63689	037 23689	037 43689	037 13689	037 33689
	150	037 53151	037 83151	037 63151	037 23151	037 43151	037 13151	037 33151
	220	037 53221	037 83221	037 63221	037 23221	037 43221	037 13221	037 33221
	330	037 90021	037 90022	037 90023	037 90024	037 90025	037 90026	037 90027
	470	037 53471	037 83471	037 63471	037 23471	037 43471	037 13471	037 33471
	1000	037 53102	037 63102	–	037 23102	–	–	–
	1500	037 53152	037 63152	–	037 23152	–	–	–
	2200	037 53222	037 63222	–	037 23222	–	–	–
	3300	037 53332	037 63332	–	037 23332	–	–	–
	6800	037 53682	037 63682	–	037 23682	–	–	–
	10 000	037 53103	037 63103	–	037 23103	–	–	–
10	47	037 54479	037 84479	037 64479	037 24479	037 44479	037 14479	037 34479
	100	037 54101	037 84101	037 64101	037 24101	037 44101	037 14101	037 34101
	150	037 54151	037 84151	037 64151	037 24151	037 44151	037 14151	037 34151
	220	037 90029	037 90031	037 90032	037 90012	037 90013	037 90035	037 90036
	330	037 54331	037 84331	037 64331	037 24331	037 44331	037 14331	037 34331
	470	037 54471	037 64471	–	037 24471	–	–	–
	680	037 54681	037 64681	–	037 24681	–	–	–
	1000	037 54102	037 64102	–	037 24102	–	–	–
	2200	037 54222	037 64222	–	037 24222	–	–	–
	3300	037 54332	037 64332	–	037 24332	–	–	–
	4700	037 54472	037 64472	–	037 24472	–	–	–
	6800	037 54682	037 64682	–	037 24682	–	–	–

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
16	33	5 x 11	11	70	8.3	4.1	0.16	9.6	9.7
	68	5 x 11	11	100	14	5.2	0.16	4.7	4.7
	100	6.3 x 11	12	140	19	6.2	0.16	3.2	3.2
	150	8 x 12	13	200	27	7.8	0.16	2.1	2.1
	220	8 x 12	13	240	38	10	0.16	1.4	1.5
	330	8 x 12	13	330	56	14	0.16	0.96	0.97
	470	10 x 12	14	420	78	18	0.16	0.68	0.68
	680	10 x 16	15	520	110	25	0.16	0.47	0.47
	1000	10 x 20	16	740	160	35	0.16	0.32	0.32
	1500	12.5 x 20	17	900	240	51	0.17	0.23	0.21
	2200	12.5 x 25	18	1150	360	73	0.18	0.16	0.15
	3300	16 x 25	19	1400	530	109	0.20	0.12	0.10
	4700	16 x 31	20	1650	760	150	0.24	0.10	0.07
25	47	5 x 11	11	90	15	5.4	0.14	5.9	4.7
	68	6.3 x 11	12	110	20	6.4	0.14	4.1	3.2
	100	6.3 x 11	12	170	28	8	0.14	2.8	2.2
	150	8 x 12	13	200	41	11	0.14	1.9	1.5
	220	8 x 12	13	280	58	14	0.14	1.3	1.0
	330	10 x 12	14	410	86	20	0.14	0.84	0.67
	470	10 x 16	15	510	120	26	0.14	0.59	0.47
	1000	12.5 x 20	17	890	250	53	0.14	0.28	0.22
	1500	12.5 x 25	18	1000	380	78	0.15	0.20	0.15
	2200	16 x 25	19	1300	550	110	0.16	0.14	0.10
	3300	16 x 31	20	1500	830	170	0.18	0.11	0.07
35	22	5 x 11	11	65	11	4.5	0.12	11	6.8
	33	5 x 11	11	80	15	5.3	0.12	7.2	4.5
	220	10 x 12	14	330	80	18	0.12	1.1	0.68
	330	10 x 16	15	450	120	26	0.12	0.72	0.45
	470	10 x 20	16	550	170	36	0.12	0.51	0.32
	680	12.5 x 20	17	740	240	51	0.12	0.35	0.22
	1000	12.5 x 25	18	990	350	73	0.12	0.24	0.15
	1500	16 x 25	19	1150	530	110	0.13	0.17	0.10
	2200	16 x 31	20	1400	770	160	0.14	0.13	0.07

U_R (V)	C_R 100 Hz (µF)	CATALOGUE NUMBER 2222						
		BULK PACKING			TAPED ON REEL			TAPED IN BOX F = 5 mm
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR−	F = 2.5 mm or 3.5 mm positive leading Form TN+	Form TFA
16	33	037 55339	037 85339	037 65339	037 25339	037 45339	037 15339	037 35339
	68	037 55689	037 85689	037 65689	037 25689	037 45689	037 15689	037 35689
	100	037 55101	037 85101	037 65101	037 25101	037 45101	037 15101	037 35101
	150	037 55151	037 85151	037 65151	037 25151	037 45151	037 15151	037 35151
	220	037 55221	037 85221	037 65221	037 25221	037 45221	037 15221	037 35221
	330	037 90038	037 90039	037 90041	037 90042	037 90043	037 90044	037 90045
	470	037 55471	037 65471	–	037 25471	–	–	–
	680	037 55681	037 65681	–	037 25681	–	–	–
	1000	037 55102	037 65102	–	037 25102	–	–	–
	1500	037 55152	037 65152	–	037 25152	–	–	–
	2200	037 55222	037 65222	–	037 25222	–	–	–
	3300	037 55332	037 65332	–	037 25332	–	–	–
	4700	037 55472	037 65472	–	037 25472	–	–	–
25	47	037 56479	037 86479	037 66479	037 26479	037 46479	037 16479	037 36479
	68	037 56689	037 86689	037 66689	037 26689	037 46689	037 16689	037 36689
	100	037 90047	037 90048	037 90049	037 90051	037 90052	037 90053	037 90054
	150	037 56151	037 86151	037 66151	037 26151	037 46151	037 16151	037 36151
	220	037 56221	037 86221	037 66221	037 26221	037 46221	037 16221	037 36221
	330	037 56331	037 66331	–	037 26331	–	–	–
	470	037 56471	037 66471	–	037 26471	–	–	–
	1000	037 56102	037 66102	–	037 26102	–	–	–
	1500	037 56152	037 66152	–	037 26152	–	–	–
	2200	037 56222	037 66222	–	037 26222	–	–	–
	3300	037 56332	037 66332	–	037 26332	–	–	–
35	22	037 50229	037 80229	037 60229	037 20229	037 40229	037 10229	037 30229
	33	037 50339	037 80339	037 60339	037 20339	037 40339	037 10339	037 30339
	220	037 50221	037 60221	–	037 20221	–	–	–
	330	037 50331	037 60331	–	037 20331	–	–	–
	470	037 50471	037 60471	–	037 20471	–	–	–
	680	037 50681	037 60681	–	037 20681	–	–	–
	1000	037 50102	037 60102	–	037 20102	–	–	–
	1500	037 50152	037 60152	–	037 20152	–	–	–
	2200	037 50222	037 60222	–	037 20222	–	–	–

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
40	15	5 x 11	11	55	9	4.2	0.12	16	8.7
	22	5 x 11	11	70	12	4.8	0.12	11	5.9
	33	6.3 x 11	12	90	16	5.6	0.12	7.2	3.9
	47	6.3 x 11	12	110	22	6.8	0.12	5.1	2.8
	68	8 x 12	13	150	30	8.4	0.12	3.5	1.9
	100	8 x 12	13	190	43	11	0.12	2.4	1.3
	150	10 x 12	14	250	63	15	0.12	1.6	0.87
	330	10 x 20	16	500	140	29	0.12	0.72	0.39
	470	12.5 x 20	17	650	190	41	0.12	0.51	0.28
	680	12.5 x 25	18	810	280	57	0.12	0.35	0.19
	1000	16 x 25	19	1050	400	83	0.12	0.24	0.13
	1500	16 x 31	20	1100	600	120	0.13	0.17	0.09
50	10	5 x 11	11	47	8	4	0.10	16	9.5
	22	5 x 11	11	81	14	5.2	0.10	7.2	4.3
	33	6.3 x 11	12	100	20	6.3	0.10	4.8	2.9
	47	6.3 x 11	12	140	27	7.7	0.10	3.4	2.0
	68	8 x 12	13	160	37	10	0.10	2.3	1.4
	100	8 x 12	13	210	53	13	0.10	1.6	0.95
	220	10 x 16	15	400	110	25	0.10	0.72	0.43
	330	10 x 20	16	580	170	36	0.10	0.48	0.29
	470	12.5 x 20	17	670	240	50	0.10	0.34	0.20
	680	12.5 x 25	18	850	340	71	0.10	0.23	0.14
	1000	16 x 25	19	1100	500	100	0.10	0.16	0.10

U_R (V)	C_R 100 Hz (μF)	CATALOGUE NUMBER 2222						
		BULK PACKING			TAPED ON REEL			TAPED IN BOX F = 5 mm
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR–	F = 2.5 mm or 3.5 mm positive leading Form TN+	Form TFA
40	15	037 57159	037 87159	037 67159	037 27159	037 47159	037 17159	037 37159
	22	037 57229	037 87229	037 67229	037 27229	037 47229	037 17229	037 37229
	33	037 57339	037 87339	037 67339	037 27339	037 47339	037 17339	037 37339
	47	037 57479	037 87479	037 67479	037 27479	037 47479	037 17479	037 37479
	68	037 57689	037 87689	037 67689	037 27689	037 47689	037 17689	037 37689
	100	037 57101	037 87101	037 67101	037 27101	037 47101	037 17101	037 37101
	150	037 57151	037 67151	–	037 27151	–	–	–
	330	037 57331	037 67331	–	037 27331	–	–	–
	470	037 57471	037 67471	–	037 27471	–	–	–
	680	037 57681	037 67681	–	037 27681	–	–	–
	1000	037 57102	037 67102	–	037 27102	–	–	–
	1500	037 57152	037 67152	–	037 27152	–	–	–
50	10	037 51109	037 81109	037 61109	037 21109	037 41109	037 11109	037 31109
	22	037 90056	037 90057	037 90058	037 90059	037 90061	037 90062	037 90063
	33	037 51339	037 81339	037 61339	037 21339	037 41339	037 11339	037 31339
	47	037 90065	037 90066	037 90067	037 90068	037 90069	037 90071	037 90072
	68	037 51689	037 81689	037 61689	037 21689	037 41689	037 11689	037 31689
	100	037 51101	037 81101	037 61101	037 21101	037 41101	037 11101	037 31101
	220	037 51221	037 61221	–	037 21221	–	–	–
	330	037 51331	037 61331	–	037 21331	–	–	–
	470	037 51471	037 61471	–	037 21471	–	–	–
	680	037 51681	037 61681	–	037 21681	–	–	–
	1000	037 51102	037 61102	–	037 21102	–	–	–

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅D x L (mm)	CASE CODE	I_R 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
63	0.10	5 x 11	11	5	3.1	3	0.09	1400	800
	0.22	5 x 11	11	8	3.1	3	0.09	650	360
	0.47	5 x 11	11	11	3.3	3.1	0.09	300	170
	1.0	5 x 11	11	16	3.6	3.1	0.09	140	80
	2.2	5 x 11	11	23	4.4	3.3	0.09	65	36
	3.3	5 x 11	11	29	5.1	3.4	0.09	43	24
	4.7	5 x 11	11	35	6.0	3.6	0.09	30	17
	6.8	5 x 11	11	41	7.3	3.9	0.09	21	12
	10	5 x 11	11	50	9.3	4.3	0.09	14	8.0
	15	5 x 11	11	61	12	4.9	0.09	9.5	5.3
	22	6.3 x 11	12	85	17	5.8	0.09	6.5	3.6
	33	6.3 x 11	12	120	24	7.2	0.09	4.3	2.4
	47	8 x 12	13	150	33	8.9	0.09	3.0	1.7
	68	10 x 12	14	200	46	12	0.09	2.1	1.2
	100	10 x 12	14	260	66	16	0.09	1.4	0.80
	150	10 x 16	15	320	98	22	0.09	0.95	0.53
	220	10 x 20	16	460	140	31	0.09	0.65	0.36
	330	12.5 x 20	17	600	210	45	0.09	0.43	0.24
	470	12.5 x 25	18	830	300	62	0.09	0.30	0.17
	680	16 x 25	19	1000	430	89	0.09	0.21	0.12
	1000	16 x 31	20	1250	630	130	0.09	0.14	0.08

U_R (V)	C_R 100 Hz (µF)	CATALOGUE NUMBER 2222						
		BULK PACKING			TAPED ON REEL			TAPED IN BOX F = 5 mm
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR–	F = 2.5 mm or 3.5 mm positive leading Form TN+	Form TFA
63	0.10	037 58107	037 88107	037 68107	037 28107	037 48107	037 18107	037 38107
	0.22	037 58227	037 88227	037 68227	037 28227	037 48227	037 18227	037 38227
	0.47	037 58477	037 88477	037 68477	037 28477	037 48477	037 18477	037 38477
	1.0	037 58108	037 88108	037 68108	037 28108	037 48108	037 18108	037 38108
	2.2	037 58228	037 88228	037 68228	037 28228	037 48228	037 18228	037 38228
	3.3	037 58338	037 88338	037 68338	037 28338	037 48338	037 18338	037 38338
	4.7	037 58478	037 88478	037 68478	037 28478	037 48478	037 18478	037 38478
	6.8	037 58688	037 88688	037 68688	037 28688	037 48688	037 18688	037 38688
	10	037 58109	037 88109	037 68109	037 28109	037 48109	037 18109	037 38109
	15	037 58159	037 88159	037 68159	037 28159	037 48159	037 18159	037 38159
	22	037 58229	037 88229	037 68229	037 28229	037 48229	037 18229	037 38229
	33	037 90074	037 90075	037 90076	037 90077	037 90078	037 90079	037 90081
	47	037 58479	037 88479	037 68479	037 28479	037 48479	037 18479	037 38479
	68	037 58689	037 68689	–	037 28689	–	–	–
	100	037 58101	037 68101	–	037 28101	–	–	–
	150	037 58151	037 68151	–	037 28151	–	–	–
	220	037 58221	037 68221	–	037 28221	–	–	–
	330	037 58331	037 68331	–	037 28331	–	–	–
	470	037 58471	037 68471	–	037 28471	–	–	–
	680	037 58681	037 68681	–	037 28681	–	–	–
	1000	037 58102	037 68102	–	037 28102	–	–	–

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz (Ω)
100	0.22	5 x 11	11	8	3.2	3	0.07	506	270
	0.47	5 x 11	11	12	3.5	3.1	0.07	237	130
	1.0	5 x 11	11	18	4	3.2	0.07	111	60
	2.2	5 x 11	11	27	5.2	3.4	0.07	51	27
	3.3	5 x 11	11	33	6.3	3.7	0.07	34	18
	4.7	5 x 11	11	39	7.7	3.9	0.07	24	13
	6.8	5 x 11	11	47	9.8	4.4	0.07	16	8.8
	10	6.3 x 11	12	62	13	5	0.07	11	6.0
	15	8 x 12	13	91	18	6	0.07	7.4	4.0
	22	8 x 12	13	115	25	7.4	0.07	5.1	2.7
	33	10 x 12	14	160	36	9.6	0.07	3.4	1.8
	47	10 x 16	15	210	50	12	0.07	2.4	1.3
	68	10 x 16	15	250	71	17	0.07	1.6	0.88
	100	10 x 20	16	350	100	23	0.07	1.1	0.60
	150	12.5 x 20	17	460	150	33	0.07	0.74	0.40
	220	12.5 x 25	18	580	220	47	0.07	0.51	0.27
	330	16 x 25	19	710	330	69	0.07	0.34	0.18
	470	16 x 31	20	900	470	97	0.07	0.24	0.13

Voltage

Surge voltage for short periods	$U_s \leq 1.15\ U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.01\ C_R \times U_R + 3\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R \times U_R + 3\ \mu A$

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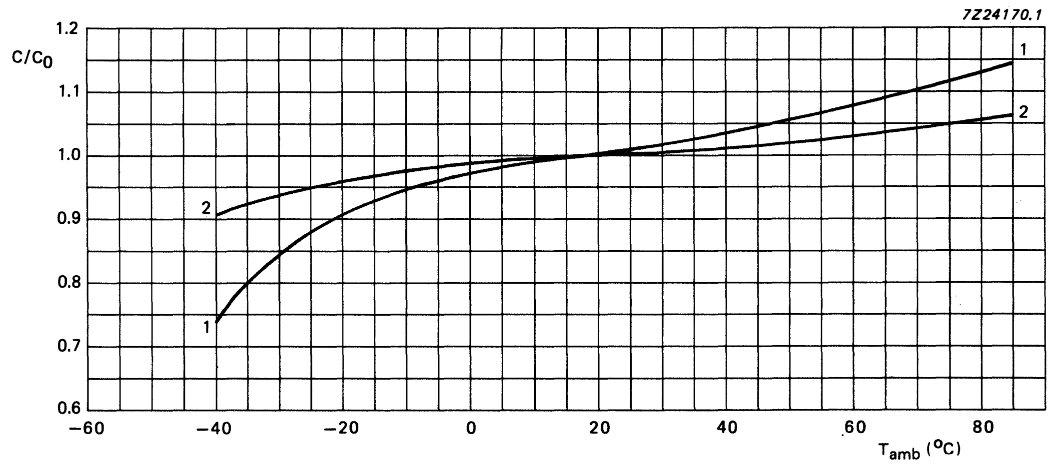
U_R (V)	C_R 100 Hz (μF)	CATALOGUE NUMBER 2222						
		BULK PACKING			TAPED ON REEL			TAPED IN BOX F = 5 mm
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR−	F = 2.5 mm or 3.5 mm positive leading Form TN+	Form TFA
100	0.22	037 59227	037 89227	037 69227	037 29227	037 49227	037 19227	037 39227
	0.47	037 59477	037 89477	037 69477	037 29477	037 49477	037 19477	037 39477
	1.0	037 59108	037 89108	037 69108	037 29108	037 49108	037 19108	037 39108
	2.2	037 59228	037 89228	037 69228	037 29228	037 49228	037 19228	037 39228
	3.3	037 59338	037 89338	037 69338	037 29338	037 49338	037 19338	037 39338
	4.7	037 59478	037 89478	037 69478	037 29478	037 49478	037 19478	037 39478
	6.8	037 59688	037 89688	037 69688	037 29688	037 49688	037 19688	037 39688
	10	037 59109	037 89109	037 69109	037 29109	037 49109	037 19109	037 39109
	15	037 59159	037 89159	037 69159	037 29159	037 49159	037 19159	037 39159
	22	037 59229	037 89229	037 69229	037 29229	037 49229	037 19229	037 39229
	33	037 59339	037 69339	–	037 29339	–	–	–
	47	037 59479	037 69479	–	037 29479	–	–	–
	68	037 59689	037 69689	–	037 29689	–	–	–
	100	037 59101	037 69101	–	037 29101	–	–	–
	150	037 59151	037 69151	–	037 29151	–	–	–
	220	037 59221	037 69221	–	037 29221	–	–	–
	330	037 59331	037 69331	–	037 29331	–	–	–
	470	037 59471	037 69471	–	037 29471	–	–	–

Marking

The capacitors are marked (where possible) with the following information:

- Rated capacitance in μF
- Tolerance on rated capacitance, code letter in accordance with IEC 62
- Rated voltage in V
- Group number (037)
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Code indicating factory of origin
- Negative terminal identification.

Capacitance (C)

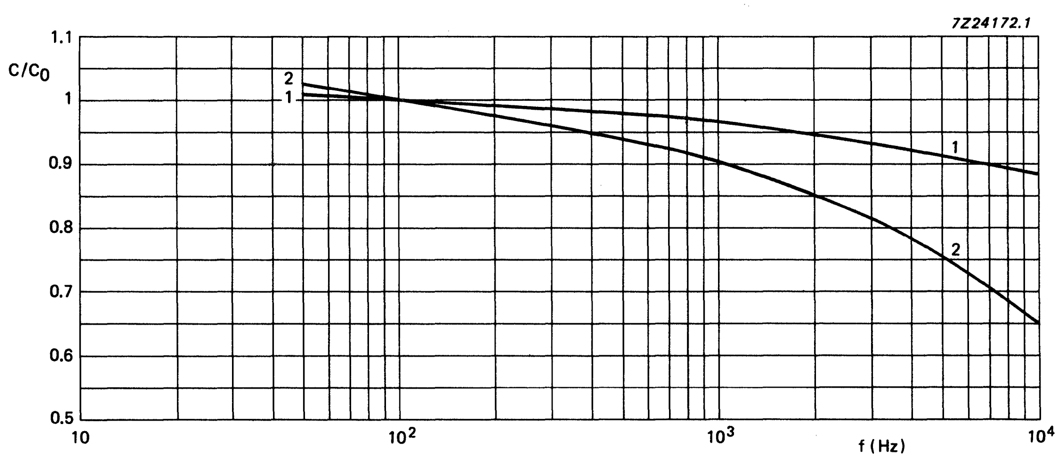


Curve 1: 6.3 V

Curve 2: 100 V.

C_o = capacitance at 20 °C, 100 Hz.

Fig.7 Typical multiplier of capacitance (C/C_o) as a function of ambient temperature.



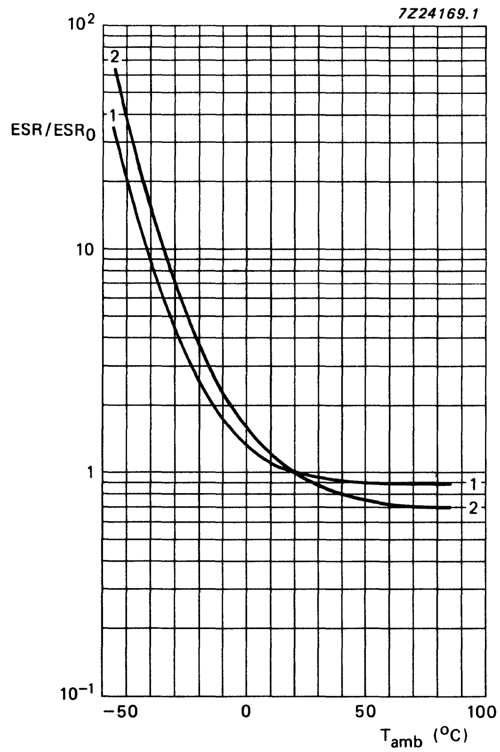
Curve 1: 100 V

Curve 2: 6.3 V.

C_o = capacitance at 20 °C, 100 Hz.

Fig.8 Typical multiplier of capacitance (C/C_o) as a function of frequency.

Equivalent series resistance (ESR)

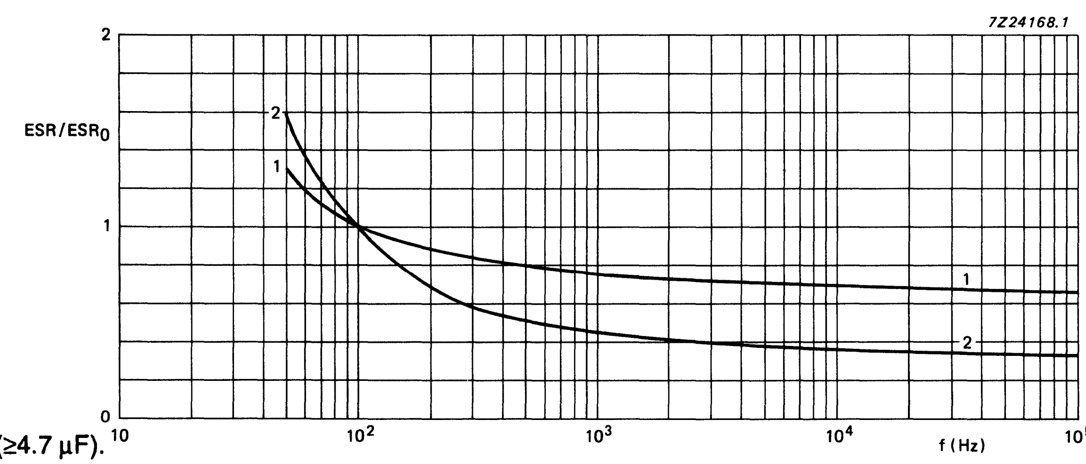


Curve 1: 63 V (≥4.7 μF)

Curve 2: 10 V.

ESR$_o$ = typical ESR at 20 °C, 100 Hz.

Fig.9 Multiplier of ESR (ESR/ESR$_o$) as a function of ambient temperature.



Curve 1 : 6.3 V

Curve 2 : 63 V (≥4.7 μF).

ESR$_o$ = typical ESR at 20 °C, 100 Hz.

Fig.10 Multiplier of ESR (ESR/ESR$_o$) as a function of frequency.

Equivalent series inductance (ESL)

case ∅ D ≤8 mm	typ. 13 nH
case ∅ D = 10 mm	typ. 16 nH
case ∅ D ≥12.5 mm	typ. 18 nH

Impedance (Z)

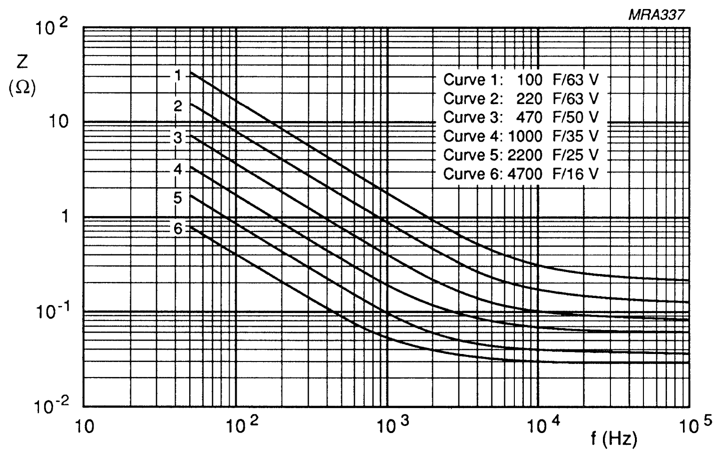
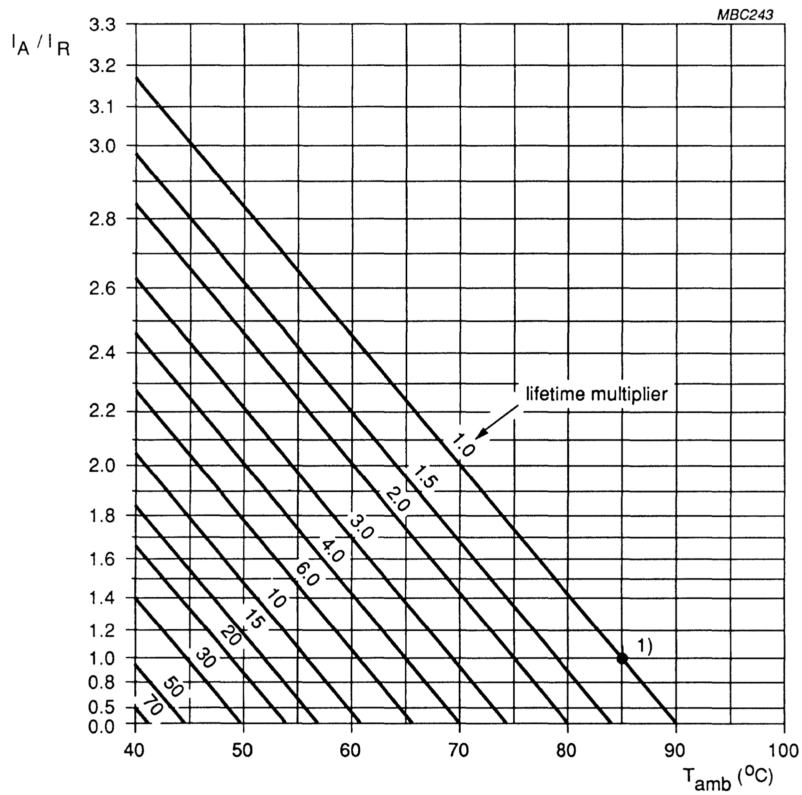


Fig.11 Typical impedance as a function of frequency at T_{amb} = 20 °C.

RIPPLE CURRENT and USEFUL LIFE

Table 5 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 100 Hz

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 to 10 V	U_R = 16 to 35 V	U_R = 40 to 100 V
50	0.9	0.85	0.8
100	1.0	1.0	1.0
300	1.12	1.2	1.25
1000	1.2	1.3	1.4
3000	1.25	1.35	1.5
≥10 000	1.3	1.4	1.6



I_A = actual ripple current at 100 Hz.

I_R = rated ripple current at 100 Hz, 85 °C.

1) Useful life at 85 °C and I_R applied: 2000 hours.

Fig.12 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30301 sub clause 4.13	T_{amb} = 85 °C, U_R applied U_R = 6.3 to 16 V 1000 hours U_R = 25 to 100 V 2000 hours	$U_R \leq 6.3$ V : $\Delta C/C$ +15/−30% $U_R > 6.3$ V : $\Delta C/C$ ±20% tan $\delta \leq 1.5$ x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied 2000 hours	$U_R \leq 6.3$ V : $\Delta C/C$ +45/−50% $U_R > 6.3$ V : $\Delta C/C$ ±50% tan $\delta \leq 3$ x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤3%
Shelf life (storage at high temp).	IEC 384-4-1/ CECC 30301 sub clause 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$\Delta C/C$, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

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NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Radial leads, cylindrical aluminium case, insulated with a blue sleeve
- Charge and discharge proof
- Standard dimensions
- High rated voltage

APPLICATIONS

- General purpose, audio-video, lighting, general industrial
- Smoothing, filtering, buffering of high voltages
- Low surface demand on printed circuit board.

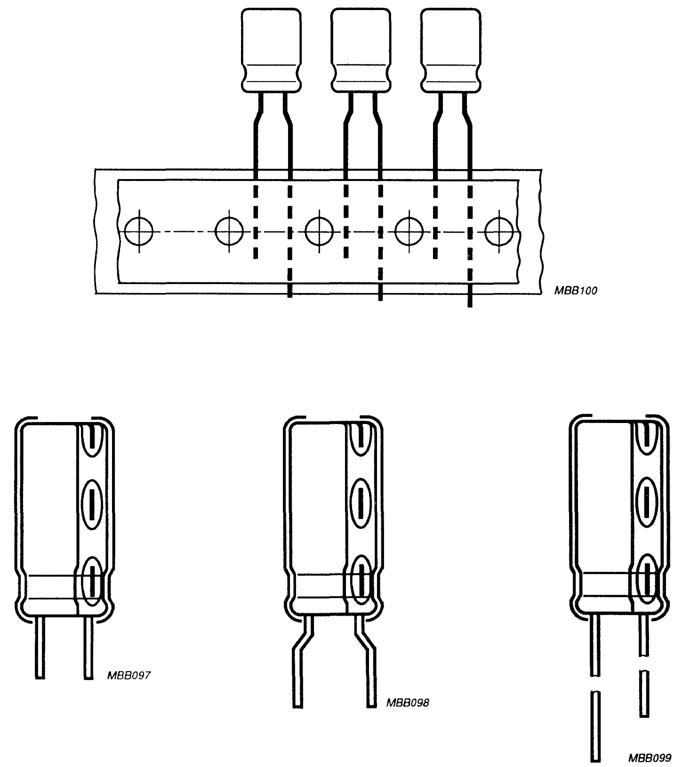

Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (∅ D_{nom} x L_{nom} in mm)	8 x 12 to 16 x 31
Rated capacitance range, C_R	1.0 to 68 µF
Tolerance on C_R	±20%
Rated voltage range, U_R	160 to 385 V
Category temperature range	–25 to +85 °C
Endurance test at 85 °C	2000 hours
Useful life at 85 °C	3000 hours
Useful life at 40 °C, 1.4 I_R applied	80 000 hours
Shelf life at 0 V, 85 °C	500 hours
Basic specification	IEC 384-4/CECC 30 300, LL grade
Detail specification	DIN 41240
Climatic category IEC 68 DIN 40040	 25/085/56 HPF

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Table 1 Selection chart for C_RU_R and relevant nominal case sizes (**∅ D x L** in **mm**)

C_R (μF)	U_R (V)				
	160	**200**	**250**	**350**	**385**
1.0			8 x 12		8 x 12
1.5			8 x 12		10 x 12
2.2			8 x 12	10 x 12	10 x 16
3.3			10 x 12		10 x 16
4.7		10 x 12	10 x 16	10 x 20	10 x 20
6.8		10 x 16	10 x 20	12.5 x 20	12.5 x 20
10	10 x 16	10 x 20	12.5 x 20	12.5 x 20	12.5 x 25
15	12.5 x 20	12.5 x 20	12.5 x 20	12.5 x 25	16 x 25
22	12.5 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31
33	12.5 x 25	12.5 x 25	16 x 25	16 x 31	
47	16 x 25	16 x 25	16 x 31		
68	16 x 31	16 x 31			

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.

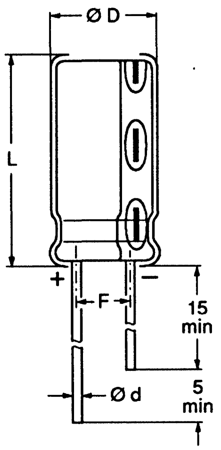


Fig.2 **Form CA**: Long leads.

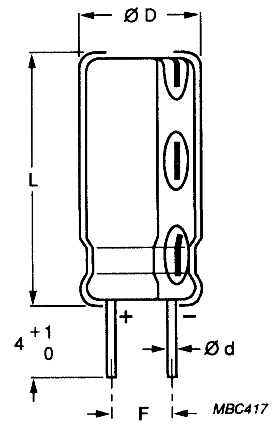


Fig.3 **Form CB**: Cut leads.

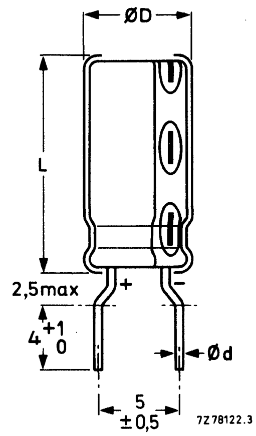
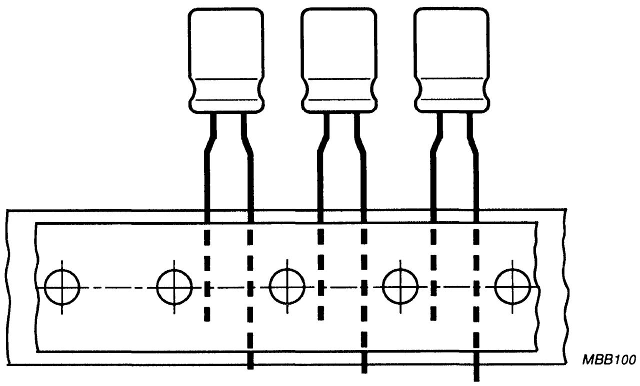


Fig.4 **Form CC**: Cut leads, formed; Ø D = 8 mm only.

Table 2 Dimensions in mm; mass in g

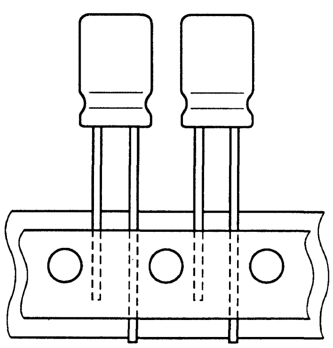
CASE SIZE Ø D_{nom} x L_{nom}	CASE CODE	Ø d	ØD_{max}	L_{max}	F ±0.5	APPROX. MASS	PACKING QUANTITIES		
							Form CA CB, CC	Form TR+ TR−, TN	Form TFA
8 x 12	13	0.6	8.5	13.0	3.5	1.1	1000	800	1000
10 x 12	14	0.6	10.5	14.0	5.0	1.6	1000	500	−
10 x 16	15	0.6	10.5	17.5	5.0	1.9	500	500	−
10 x 20	16	0.6	10.5	21.5	5.0	2.2	500	500	−
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0	200	200	−
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0	200	200	−
16 x 25	19	0.8	16.5	27.0	7.5	8.0	200	150	−
16 x 31	20	0.8	16.5	33.5	7.5	9.0	200	150	−

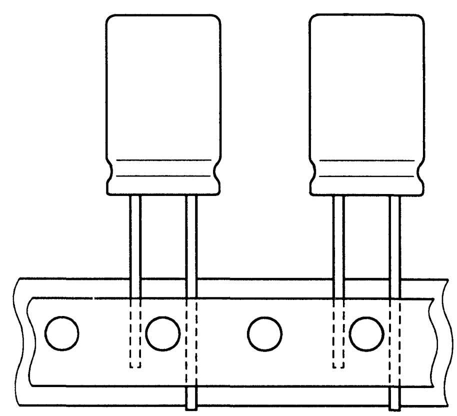
Taping dimensions are specified in chapter "PACKING".



Form TR+: Taped on reel, positive leading.
Form TR–: Taped on reel, negative leading.
Form TFA : Taped in box (ammopack).

Fig.5 Taped, formed, pitch 5 mm; ∅ D = 8 mm only.





Form TR+:
∅D 10 and 12.5 mm: F = 5 mm

Form TR+:
∅D 16 mm: F = 7.5 mm

Fig.6 Taped on reel, straight leads, positive leading.

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 3 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	=	rated capacitance at 100 Hz, tolerance ± 20%
I_R	=	rated RMS ripple current at 100 Hz, 85 °C
I_{L1}	=	max. leakage current after 1 minute at U_R
I_{L5}	=	max. leakage current after 5 minutes at U_R
tan δ	=	max. dissipation factor at 100 Hz
ESR	=	equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	=	max. impedance at 10 kHz and 20 or –25 °C.

Table 3 Electrical data

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz 20 °C (Ω)	Z 10 kHz –25 °C (Ω)
160	10	10 x 16	15	75	58	14	0.12	19	12.0	180
	15	12.5 x 20	17	115	82	18	0.12	13	8.0	120
	22	12.5 x 20	17	140	120	25	0.12	8.7	5.5	82
	33	12.5 x 25	18	180	170	36	0.12	5.8	3.6	55
	47	16 x 25	19	220	240	49	0.12	4.1	2.6	38
	68	16 x 31	20	300	340	69	0.12	2.8	1.8	26
200	4.7	10 x 12	14	45	38	9.6	0.12	41	26	380
	6.8	10 x 16	15	60	51	12	0.12	28	18	260
	10	10 x 20	16	85	70	16	0.12	19	12	180
	15	12.5 x 20	17	115	100	22	0.12	13	8	120
	22	12.5 x 20	17	140	140	30	0.12	8.7	5.5	82
	33	12.5 x 25	18	180	210	44	0.12	5.8	3.6	55
	47	16 x 25	19	220	290	60	0.12	4.1	2.6	38
	68	16 x 31	20	300	420	86	0.12	2.8	1.8	26
250	1.0	8 x 12	13	20	65	23	0.20	320	120	1800
	1.5	8 x 12	13	20	78	26	0.20	210	80	1200
	2.2	8 x 12	13	25	97	32	0.20	140	55	820
	3.3	10 x 12	14	40	35	9.0	0.10	48	36	550
	4.7	10 x 16	15	50	45	11	0.10	34	26	380
	6.8	10 x 20	16	65	61	14	0.10	23	18	260
	10	12.5 x 20	17	95	85	19	0.10	16	12	180
	15	12.5 x 20	17	115	120	27	0.10	11	8	120
	22	12.5 x 25	18	160	180	37	0.10	7.2	5.5	82
	33	16 x 25	19	190	260	54	0.10	4.8	3.6	55
	47	16 x 31	20	240	360	75	0.10	3.4	2.6	38

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 044 . . . . .
47 µF/250 V, ±20%
Case size 16 x 31 mm; Form CA
Catalogue number: 2222 044 53479.

Table 4 Ordering information

U_R (V)	C_R 100 Hz (µF)	CATALOGUE NUMBER 2222					
		BULK PACKING			TAPED ON REEL		TAPED IN BOX F = 5 mm Form TFA
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR−	
160	10	044 51109	044 61109	–	044 21109	–	–
	15	044 51159	044 61159	–	044 21159	–	–
	22	044 51229	044 61229	–	044 21229	–	–
	33	044 51339	044 61339	–	044 21339	–	–
	47	044 51479	044 61479	–	044 21479	–	–
	68	044 51689	044 61689	–	044 21689	–	–
200	4.7	044 52478	044 62478	–	044 22478	–	–
	6.8	044 52688	044 62688	–	044 22688	–	–
	10	044 52109	044 62109	–	044 22109	–	–
	15	044 52159	044 62159	–	044 22159	–	–
	22	044 52229	044 62229	–	044 22229	–	–
	33	044 52339	044 62339	–	044 22339	–	–
	47	044 52479	044 62479	–	044 22479	–	–
	68	044 52689	044 62689	–	044 22689	–	–
250	1.0	044 90002	044 90003	044 90004	044 90005	044 90007	044 90006
	1.5	044 90008	044 90009	044 90011	044 90012	044 90014	044 90013
	2.2	044 90015	044 90016	044 90017	044 90018	044 90021	044 90019
	3.3	044 53338	044 63338	–	044 23338	–	–
	4.7	044 53478	044 63478	–	044 23478	–	–
	6.8	044 53688	044 63688	–	044 23688	–	–
	10	044 53109	044 63109	–	044 23109	–	–
	15	044 53159	044 63159	–	044 23159	–	–
	22	044 53229	044 63229	–	044 23229	–	–
	33	044 53339	044 63339	–	044 23339	–	–
	47	044 53479	044 63479	–	044 23479	–	–

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 100 Hz 85 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz 20 °C (Ω)	Z 10 kHz –25 °C (Ω)
350	2.2	10 x 12	14	30	33	8.6	0.10	72	39	550
	4.7	10 x 20	16	60	59	14	0.10	34	18	260
	6.8	12.5 x 20	17	70	81	18	0.10	23	13	180
	10	12.5 x 20	17	85	120	25	0.10	16	8.5	120
	15	12.5 x 25	18	120	170	36	0.10	11	5.7	80
	22	16 x 25	19	160	240	50	0.10	7.2	3.9	55
	33	16 x 31	20	210	360	73	0.10	4.8	2.6	36
385	1.0	8 x 12	13	20	80	27	0.25	400	85	1200
	1.5	10 x 12	14	25	27	7.5	0.10	110	57	800
	2.2	10 x 16	15	35	35	9.1	0.10	72	39	550
	3.3	10 x 16	15	45	48	12	0.10	48	26	360
	4.7	10 x 20	16	60	64	15	0.10	34	18	260
	6.8	12.5 x 20	17	70	89	20	0.10	23	13	180
	10	12.5 x 25	18	90	130	27	0.10	16	8.5	120
	15	16 x 25	19	125	180	39	0.10	11	5.7	80
	22	16 x 31	20	165	260	55	0.10	7.2	3.9	55

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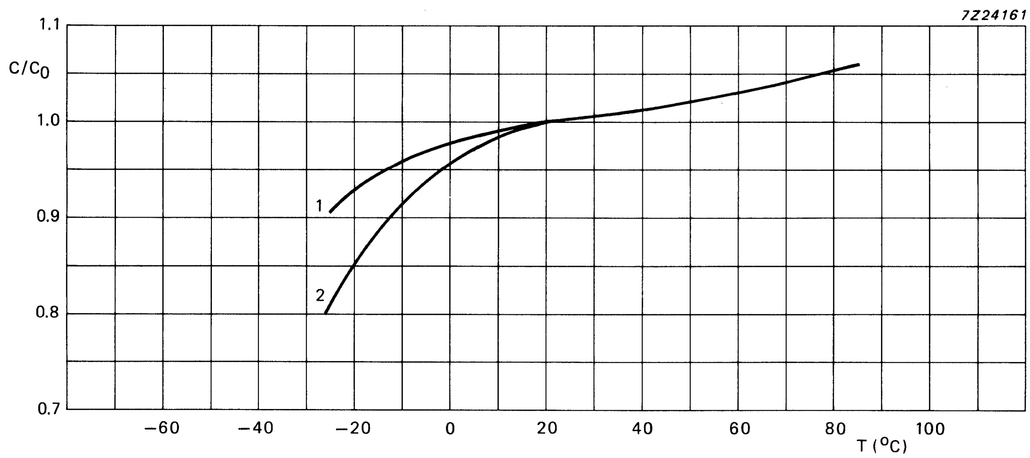
U_R (V)	C_R 100 Hz (μF)	CATALOGUE NUMBER 2222					
		BULK PACKING			TAPED ON REEL		TAPED IN BOX F = 5 mm Form TFA
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR–	
350	2.2	044 55228	044 65228	–	044 25228	–	–
	4.7	044 55478	044 65478	–	044 25478	–	–
	6.8	044 55688	044 65688	–	044 25688	–	–
	10	044 55109	044 65109	–	044 25109	–	–
	15	044 55159	044 65159	–	044 25159	–	–
	22	044 55229	044 65229	–	044 25229	–	–
	33	044 55339	044 65339	–	044 25339	–	–
385	1.0	044 90022	044 90023	044 90024	044 90025	044 90027	044 90026
	1.5	044 58158	044 68158	–	044 28158	–	–
	2.2	044 58228	044 68228	–	044 28228	–	–
	3.3	044 58338	044 68338	–	044 28338	–	–
	4.7	044 58478	044 68478	–	044 28478	–	–
	6.8	044 58688	044 68688	–	044 28688	–	–
	10	044 58109	044 68109	–	044 28109	–	–
	15	044 58159	044 68159	–	044 28159	–	–
	22	044 58229	044 68229	–	044 28229	–	–

Marking

The capacitors are marked (where possible) with the following information:

- Rated capacitance in μF
- Tolerance on rated capacitance, code letter in accordance with IEC 62
- Rated voltage in V
- Group number (044)
- Name of manufacturer (PHILIPS)
- Date code, in accordance with IEC 62
- Code indicating factory of origin
- Negative terminal identification.

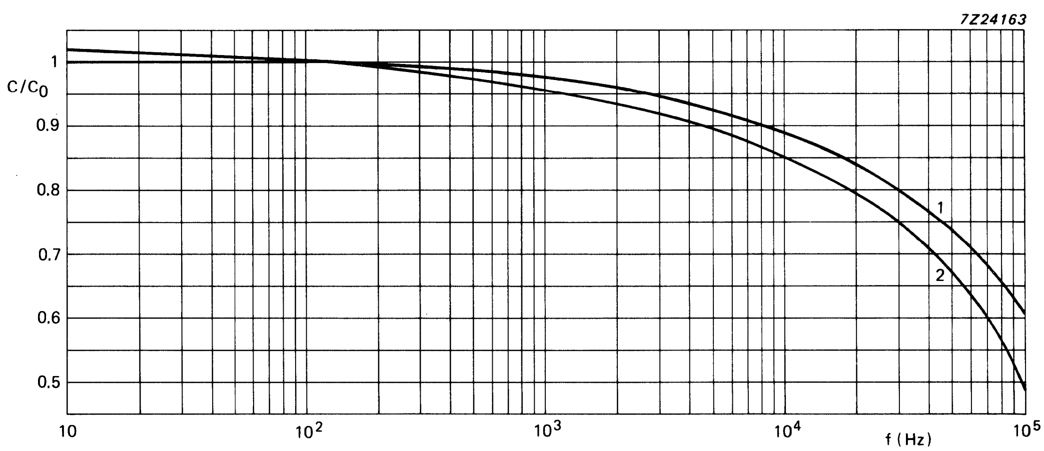
Capacitance (C)



Curve 1: 160 to 250 V
Curve 2: 350 and 385 V.

C_0 = capacitance at 20 °C, 100 Hz.

Fig.7 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature.



Curve 1: 160 to 250 V
Curve 2: 350 and 385 V.

C_0 = capacitance at 20 °C, 100 Hz.

Fig.8 Typical multiplier of capacitance (C/C_0) as a function of frequency.

Voltage

Surge voltage for short periods

160 to 250 V types	$U_s \leq 1.15 \times U_R$
350 and 385 V types	$U_s \leq 1.1 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R

case size 8 x 12	$I_{L1} \leq 0.1\, C_R \times U_R + 40\ \mu A$
case sizes 10 x 12 to 16 x 31	$I_{L1} \leq 0.03\, C_R \times U_R + 10\ \mu A$

After 5 minutes at U_R

case size 8 x 12	$I_{L5} \leq 0.03\, C_R \times U_R + 15\ \mu A$
case sizes 10 x 12 to 16 x 31	$I_{L5} \leq 0.006\, C_R \times U_R + 4\ \mu A$

Equivalent series inductance (ESL)

case ∅ D = 8 mm	typ. 13 nH
case ∅ D = 10 mm	typ. 16 nH
case ∅ D ≥12.5 mm	typ. 18 nH

Impedance (Z)

Ratio of impedance at 100 Hz:

Z at –25 °C / Z at 20 °C ≤3.

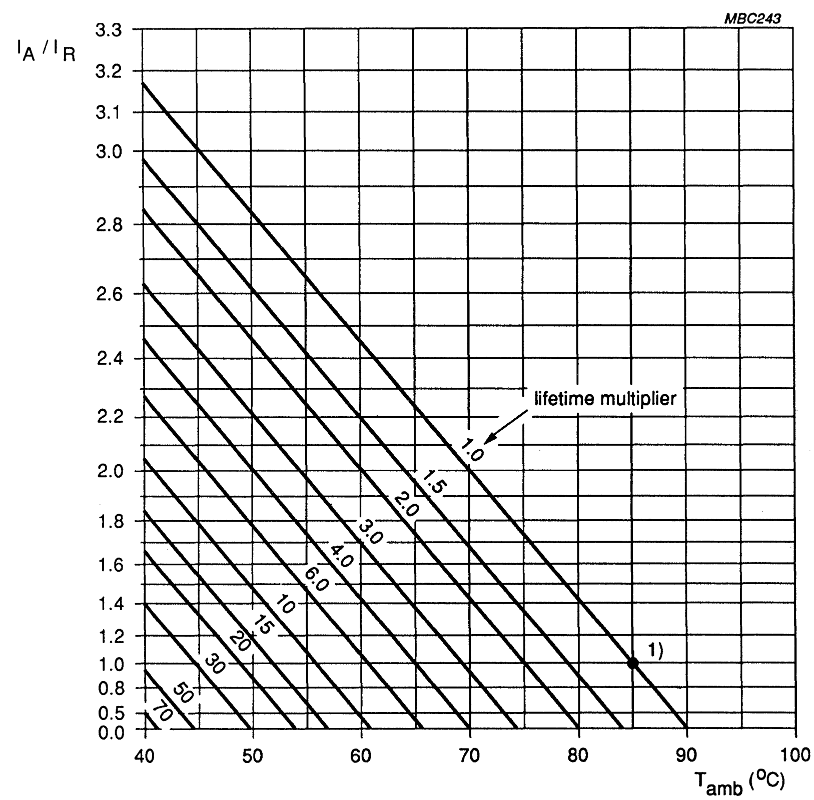
Table 5 Impedance x capacitance values at 10 kHz

T_{amb}	$z = Z \times C_R$ (Ω µF) at 10 kHz				
	160 V	200 V	250 V	350 V	385 V
+20 °C	≤ 120	≤ 120	≤ 120	≤ 85	≤ 85
–25 °C	≤ 1800	≤ 1800	≤1800	≤ 1200	≤ 1200

RIPPLE CURRENT and USEFUL LIFE

Table 6 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 100 Hz

FREQUENCY (Hz)	I_R MULTIPLIER
50	0.75
100	1.0
300	1.2
1000	1.35
3000	1.45
≥10 000	1.5



I_A = actual ripple current at 100 Hz.
I_R = rated ripple current at 100 Hz, 85 °C.

1) Useful life at 85 °C and I_R applied: 3000 hours.

Fig.9 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements".

Table 7

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301 sub clause 4.13	T_{amb} = 85 °C, U_R applied 2000 hours	U_R ≤160 V : ΔC/C ±15% U_R >160 V : ΔC/C ±10% tan δ ≤ 1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 85 °C, U_R and I_R applied 3000 hours	U_R ≤160 V : ΔC/C ±45% U_R >160 V : ΔC/C ±30% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤spec. limit no short or open circuit total failure percentage: ≤3%
Shelf life (storage at high temp).	IEC 384-4-1/ CECC 30 301 sub clause 4.17	T_{amb} = 85 °C, no voltage applied 500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, non solid
- Radial leads, cylindrical aluminium case with safety vent insulated with a blue sleeve
- Charge and discharge proof
- Long useful life 1500 h/105 °C
- High ripple current capability, low impedance

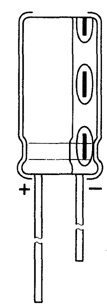


Fig.1 Component outline

APPLICATIONS

- EDP, telecommunication, industrial and audio-video
- Smoothing, filtering, buffering in SMPS
- Low PCB surface demand

QUICK REFERENCE DATA

Case size, øD_{nom} x L_{nom} in mm	10 x 12 to 18 x 40
Rated capacitance range, C_R	47 to 6800 μF
Tolerance on C_R	±20 %
Rated voltage range, U_R	16 to 63 V
Category temperature range	–40 to +105 °C
Endurance test at 105 °C	1000 hours
Useful life at 105 °C	1500 hours
Useful life at 40 °C, 1,3 I_R applied	150000 hours
Shelf life at 0 V, 105 °C	500 hours
Basic specification	IEC 384-4, L.L. grade, CECC 30 300
Detail specification	DIN 41 259
Climatic category IEC 68	40/105/56
Climatic category DIN 40 040	GMF

Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (diameter x length in mm)

C_R	U_R (V)					
μF	16	25	35	40	50	63
47 *	For lower capacitance values see RSP 036 series					10 x 12
68					10 x 12	10 x 16
100 *				10 x 12	10 x 16	10 x 20
150			10 x 12	10 x 16	10 x 20	12.5 x 20
220 *	10 x 12		10 x 16	10 x 20	12.5 x 20	12.5 x 25
330	10 x 16		10 x 20	12.5 x 20	12.5 x 25	16 x 25
470 *	10 x 20		12.5 x 20	12.5 x 25		16 x 25
680	12.5 x 20		12.5 x 25		16 x 25	16 x 31
1000 *	12.5 x 25		16 x 25		16 x 31	18 x 35
1500	16 x 25		16 x 31	16 x 35	18 x 35	18 x 40
2200 *	16 x 25	16 x 31	18 x 35	18 x 35	18 x 40	
3300	16 x 31	18 x 35		18 x 40		
4700 *	18 x 35	18 x 40				
6800	18 x 40					

* E3 values = preferred values

MECHANICAL DATA Dimensions (in mm)

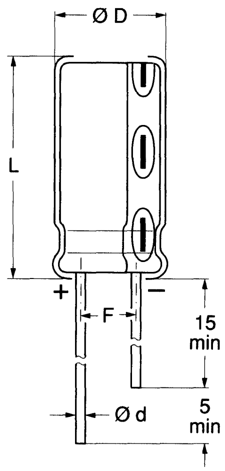


Fig. 2 **Form CA**, long leads; see Table 2 for dimensions.

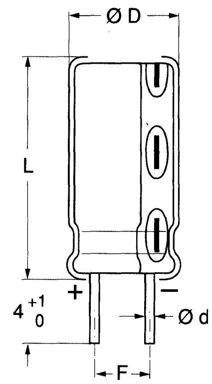
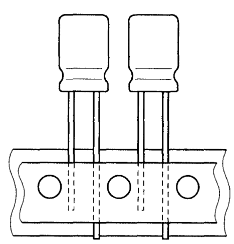
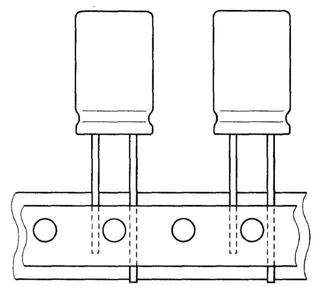


Fig. 3 **Form CB**, cut leads; see Table 2 for dimensions.



øD = 10 mm and 12.5 mm



øD = 16 mm

Fig. 4 **Form TR+**, case sizes up to ø16 x 31 taped on reel, positive leading. See Introduction for taping dimensions.

MARKING

The capacitors are marked with the following information:

- Rated capacitance value
- Tolerance on rated capacitance (M for ±20 %)
- Rated voltage
- Negative terminal identification
- Upper category temperature (105 °C)
- Group number (045)
- Code indicating factory of origin
- Name of manufacturer, PHILIPS
- Date code, in accordance with IEC 62

Table 2 Dimensions (in mm)

CASE SIZE $øD_{nom}$ x L_{nom}	CASE CODE	RADIAL				MASS (g)
		ød	$øD_{max}$	L_{max}	F ± 0,5	
10 x 12	14	0.6	10.5	13.5	5.0	1.6
10 x 16	15	0.6	10.5	17.5	5.0	1.9
10 x 20	16	0.6	10.5	21.5	5.0	2.2
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0
16 x 25	19	0.8	16.5	27.0	7.5	8.0
16 x 31	20	0.8	16.5	33.0	7.5	9.0
16 x 35	21	0.8	16.5	37.0	7.5	11.5
18 x 35	22	0.8	18.5	37.0	7.5	14.5
18 x 40	23	0.8	18.5	42.0	7.5	16.0

PACKING

Capacitors of Form CA and Form CB are supplied in boxes, those of Form TR+ taped on reel. The numbers per box and per reel are given in Table 3.

Table 3 Packing quantities

CASE SIZE $øD_{nom}$ x L_{nom}	CASE CODE	NUMBER OF CAPACITORS		
		FORM CA per Box	FORM CB per Box	FORM TR+ per Reel
10 x 12	14	1000	1000	500
10 x 16	15	500	500	500
10 x 20	16	500	500	500
12.5 x 20	17	200	200	200
12.5 x 25	18	200	200	200
16 x 25	19	200	200	150
16 x 31	20	200	200	150
16 x 35	21	150	150	
18 x 35	22	100	100	
18 x 40	23	100	100	

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Table 4 apply at an ambient temperature of 20 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75 %.

C_R	=	rated capacitance at 100 Hz, tolerance ±20 %
I_R	=	rated RMS ripple current at 100 Hz, 105 °C
I_{L1}	=	max. leakage current after 1 minute at U_R
I_{L5}	=	max. leakage current after 5 minutes at U_R
tan δ	=	max. dissipation factor at 100 Hz
ESR	=	equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	=	max. impedance at 10 kHz or 100 kHz

Table 4 Electrical data

U_R (V)	C_R (μF)	CASE SIZE $øD_{nom}$ x L_{nom} (mm)	I_R (mA)	I_{L1} (μA)	I_{L5} (μA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
16	220	10 x 12	230	73	10	0.16	1.00		0.59
	330	10 x 16	290	110	14	0.16	0.69		0.39
	470	10 x 20	380	150	18	0.16	0.49		0.28
	680	12.5 x 20	490	220	25	0.16	0.34		0.19
	1000	12.5 x 25	650	320	35	0.16	0.23		0.13
	1500	16 x 25	830	480	51	0.18	0.17	0.10	
	2200	16 x 25	950	710	73	0.20	0.13	0.07	
	3300	16 x 31	1200	1100	110	0.22	0.10	0.05	
	4700	18 x 35	1500	1500	150	0.24	0.07	0.04	
	6800	18 x 40	1700	2200	220	0.28	0.06	0.03	
25	2200	16 x 31	1100	1100	110	0.18	0.12	0.05	
	3300	18 x 35	1300	1700	170	0.20	0.09	0.04	
	4700	18 x 40	1600	2400	240	0.22	0.07	0.03	
35	150	10 x 12	240	110	14	0.12	1.10		0.57
	220	10 x 16	290	160	18	0.12	0.78		0.39
	330	10 x 20	390	230	26	0.12	0.52		0.26
	470	12.5 x 20	500	330	36	0.12	0.37		0.18
	680	12.5 x 25	660	480	51	0.12	0.25		0.13
	1000	16 x 25	880	700	73	0.12	0.17		0.09
	1500	16 x 31	1100	1100	110	0.13	0.12	0.07	
	2200	18 x 35	1400	1500	160	0.14	0.09	0.05	

ORDERING EXAMPLE

Electrolytic capacitors 2222 045 . . . . .
1000 μF/35 V, ±20 %
16 x 25, taped on reel, Form TR+
Catalogue number 2222 045 20102

Ordering information

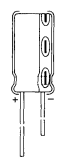
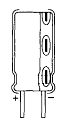
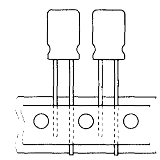
U_R	C_R	CASE SIZE $øD_{nom}$ x L_{nom}	CATALOGUE NUMBER 2222		
					
(V)	(μF)	(mm)	Form CA	Form CB	Form TR+
16	220	10 x 12	045 55221	045 65221	045 25221
	330	10 x 16	55331	65331	25331
	470	10 x 20	55471	65471	25471
	680	12.5 x 20	55681	65681	25681
	1000	12.5 x 25	55102	65102	25102
	1500	16 x 25	55152	65152	25152
	2200	16 x 25	55222	65222	25222
	3300	16 x 31	55332	65332	25332
	4700	18 x 35	55472	65472	
	6800	18 x 40	55682	65682	
25	2200	16 x 31	045 56222	045 66222	045 26222
	3300	18 x 35	56332	66332	
	4700	18 x 40	56472	66472	
35	150	10 x 12	045 50151	045 60151	045 20151
	220	10 x 16	50221	60221	20221
	330	10 x 20	50331	60331	20331
	470	12.5 x 20	50471	60471	20471
	680	12.5 x 25	50681	60681	20681
	1000	16 x 25	50102	60102	20102
	1500	16 x 31	50152	60152	20152
	2200	18 x 35	50222	60222	

Table 4 Electrical data (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom} \times L_{nom}$ (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
40	100	10 x 12	190	83	13	0.12	1.70		0.80
	150	10 x 16	250	120	15	0.12	1.10		0.53
	220	10 x 20	320	180	21	0.12	0.78		0.36
	330	12.5 x 20	420	270	29	0.12	0.52		0.24
	470	12.5 x 25	540	380	41	0.12	0.37		0.17
	1500	16 x 35	1200	1200	130	0.13	0.12	0.06	
	2200	18 x 35	1400	1800	180	0.14	0.09	0.04	
	3300	18 x 40	1700	2600	270	0.15	0.07	0.03	
50	68	10 x 12	170	71	11	0.10	2.10		0.96
	100	10 x 16	220	100	13	0.10	1.40		0.65
	150	10 x 20	280	150	18	0.10	0.96		0.43
	220	12,5 x 20	380	220	25	0.10	0.65		0.30
	330	12,5 x 25	510	330	36	0.10	0.43		0.20
	680	16 x 25	800	680	71	0.10	0.21		0.10
	1000	16 x 31	1100	1000	100	0.10	0.14		0.07
	1500	18 x 35	1300	1500	150	0.11	0.11	0.05	
	2200	18 x 40	1600	2200	220	0.12	0.08	0.03	
63	47	10 x 12	150	62	9	0.08	2.60		1.30
	68	10 x 16	190	89	12	0.08	1.80		0.88
	100	10 x 20	250	130	16	0.08	1.20		0.60
	150	12,5 x 20	340	190	22	0.08	0.81		0.40
	220	12,5 x 25	450	280	31	0.08	0.55		0.27
	330	16 x 25	600	420	45	0.08	0.37		0.18
	470	16 x 25	710	600	62	0.08	0.26		0.13
	680	16 x 31	930	860	89	0.08	0.18		0.09
	1000	18 x 35	1200	1300	130	0.08	0.12		0.06
	1500	18 x 40	1500	1900	190	0.09	0.09	0.04	

Voltage

Surge voltage for short periods	$U_s \leq 1.15 \times U_R$
Reverse voltage	$U_{rev} \leq 1$ V

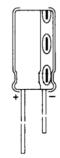
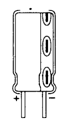
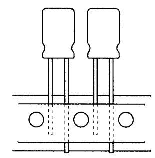
Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.02\ C_R\ U_R + 3\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R\ U_R + 3\ \mu A$

Equivalent series inductance (ESL)

Case diameter = 10 mm	typ. 16 nH
Case diameter ≥ 12,5 mm	typ. 18 nH

Ordering information (continued)

U_R (V)	C_R (μF)	CASE SIZE $øD_{nom}$ x L_{nom} (mm)	CATALOGUE NUMBER 2222 ... .  Form CA	 Form CB	 Form TR+
40	100	10 x 12	045 57101	045 67101	045 27101
	150	10 x 16	57151	67151	27151
	220	10 x 20	57221	67221	27221
	330	12.5 x 20	57331	67331	27331
	470	12.5 x 25	57471	67471	27471
	1500	16 x 35	57152	67152	
	2200	18 x 35	57222	67222	
	3300	18 x 40	57332	67332	
50	68	10 x 12	045 51689	045 61689	045 21689
	100	10 x 16	51101	61101	21101
	150	10 x 20	51151	61151	21151
	220	12,5 x 20	51221	61221	21221
	330	12,5 x 25	51331	61331	21331
	680	16 x 25	51681	61681	21681
	1000	16 x 31	51102	61102	21102
	1500	18 x 35	51152	61152	
	2200	18 x 40	51222	61222	
63	47	10 x 12	045 58479	045 68479	045 28479
	68	10 x 16	58689	68689	28689
	100	10 x 20	58101	68101	28101
	150	12,5 x 20	58151	68151	28151
	220	12,5 x 25	58221	68221	28221
	330	16 x 25	58331	68331	28331
	470	16 x 25	58471	68471	28471
	680	16 x 31	58681	68681	28681
	1000	18 x 35	58102	68102	
	1500	18 x 40	58152	68152	

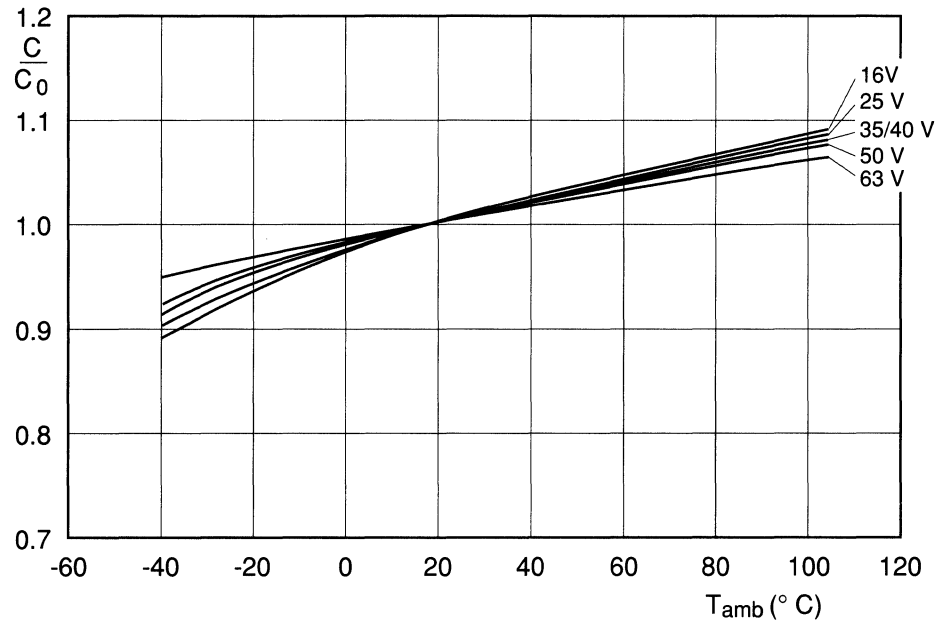


Fig. 5 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature;
C_0 = Capacitance at 20 °C, 100 Hz.

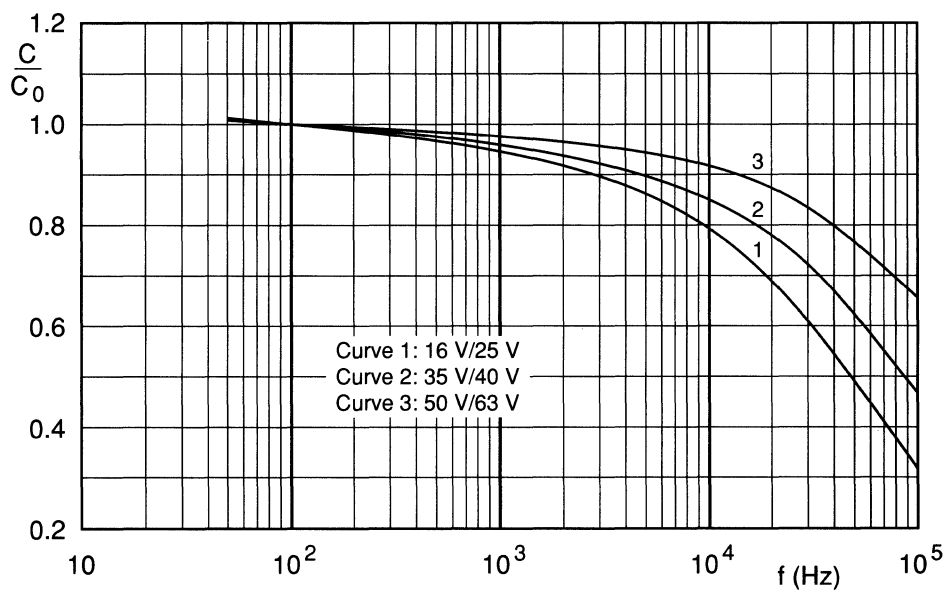


Fig. 6 Typical multiplier of capacitance (C/C_0) as a function of frequency;
C_0 = Capacitance at 20 °C, 100 Hz.

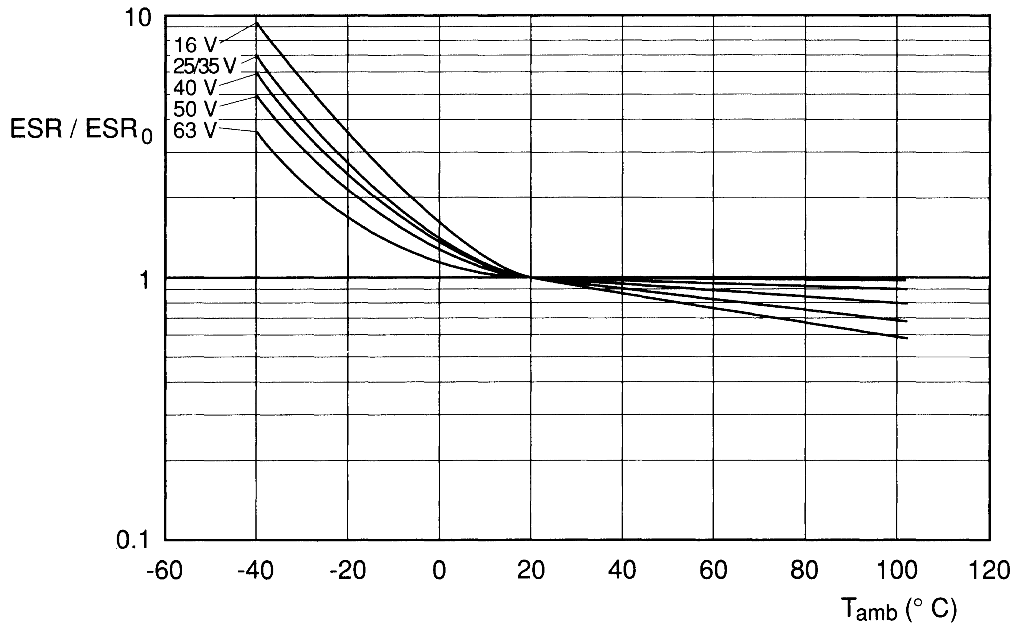


Fig. 7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature;
ESR_0 = typical ESR at 20 °C, 100 Hz.

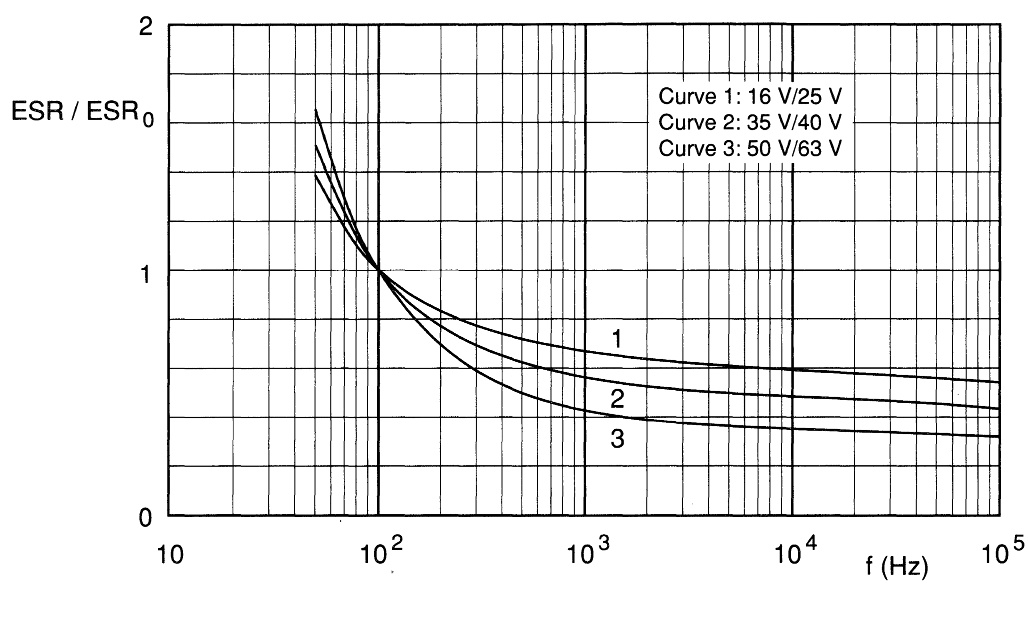


Fig. 8 Multiplier of ESR (ESR/ESR_0) as a function of frequency;
ESR_0 = typical ESR at 20 °C, 100 Hz.

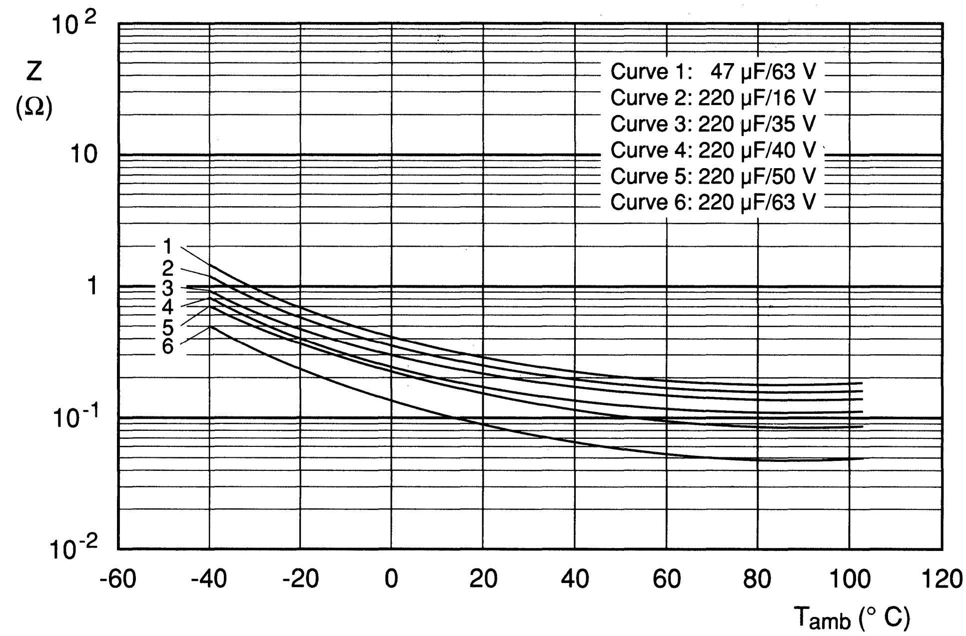


Fig. 9 Typical impedance at 100 kHz as a function of ambient temperature.

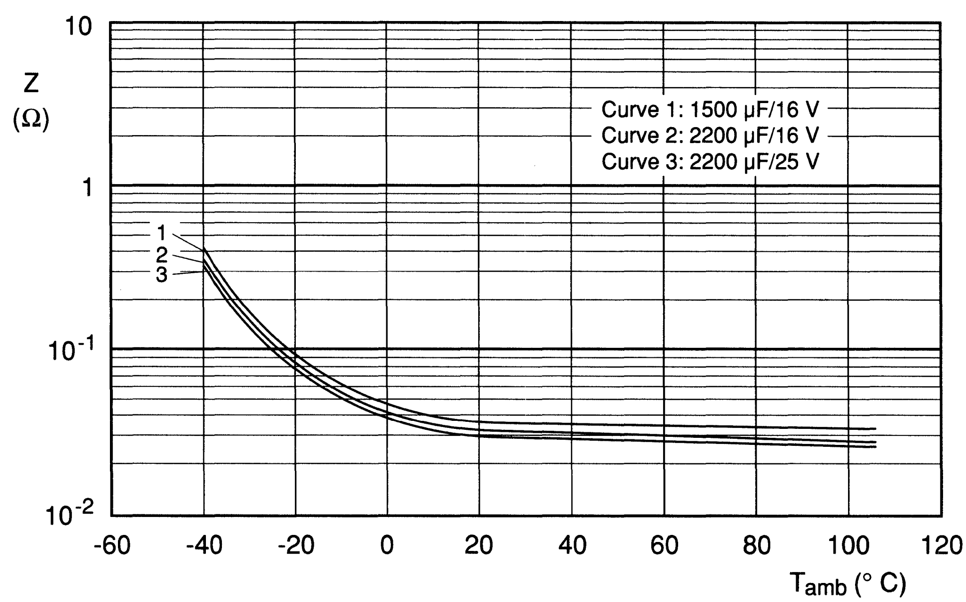


Fig. 10 Typical impedance at 10 kHz as a function of ambient temperature.

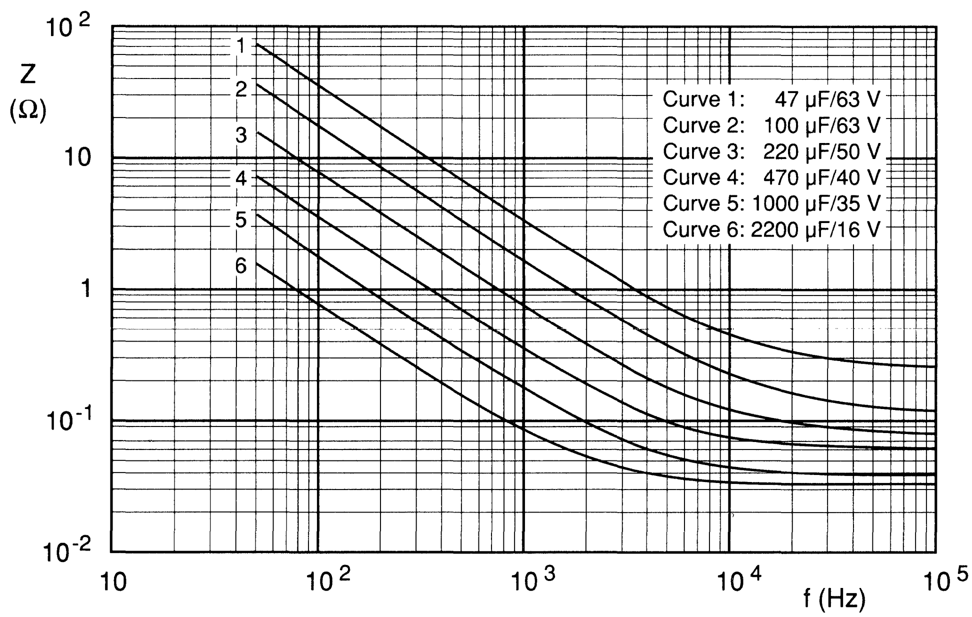


Fig. 11 Typical impedance as a function of frequency at T_{amb} = 20 °C.

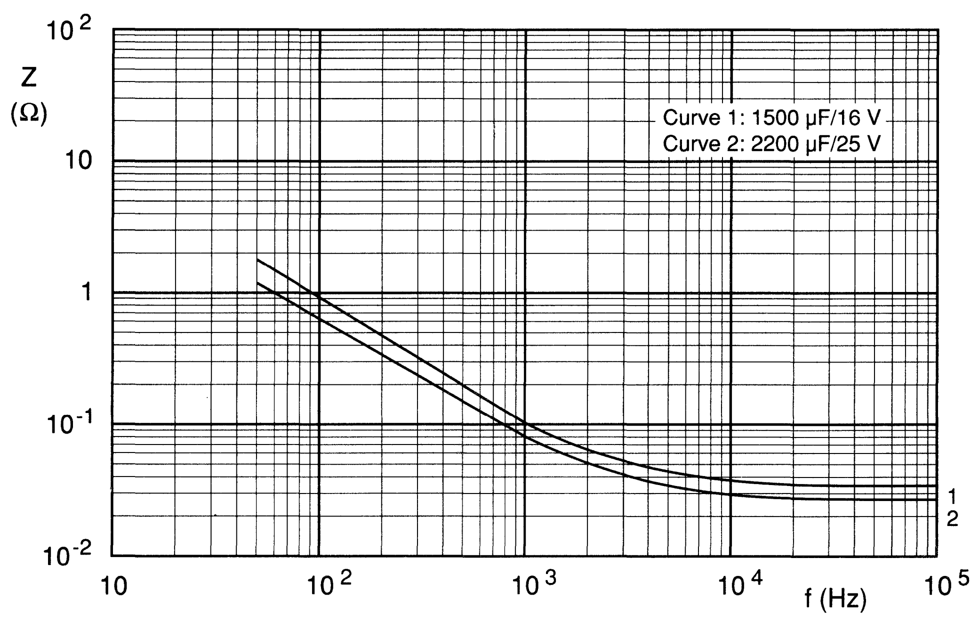


Fig. 12 Typical impedance as a function of frequency at T_{amb} = 20 °C.

USEFUL LIFE

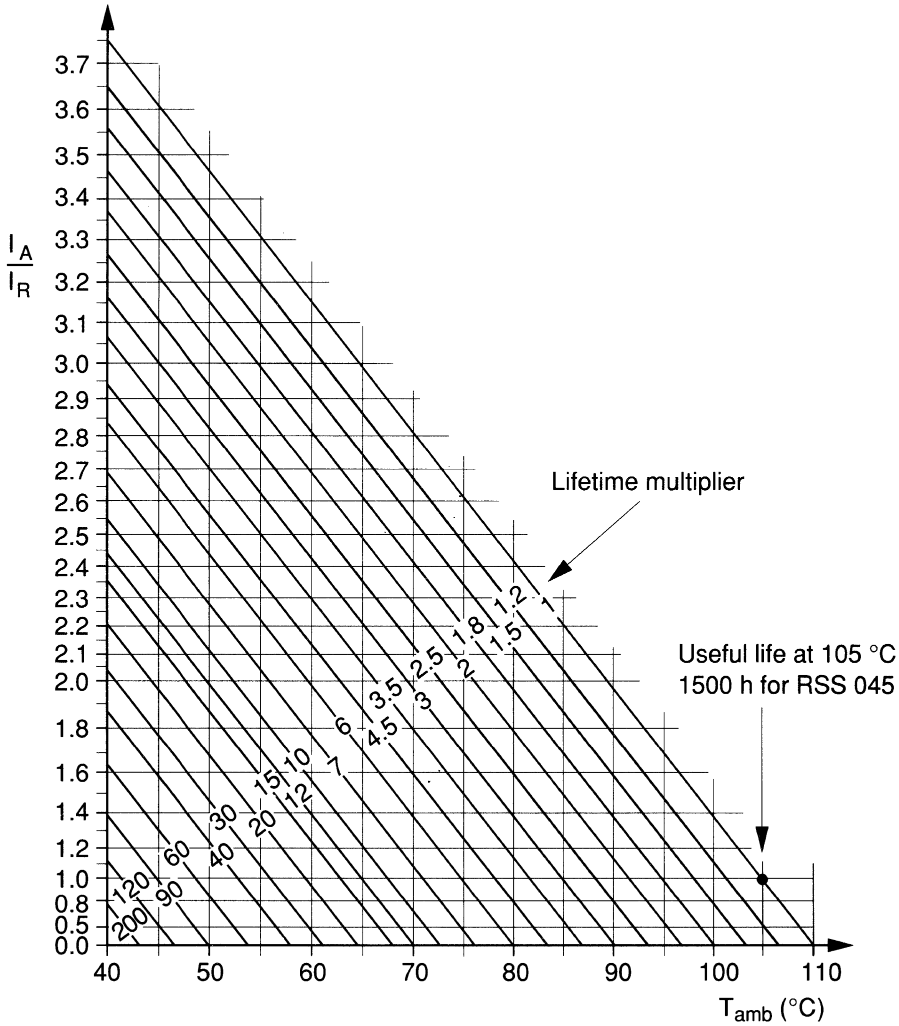


Fig. 13 Life expectancy (useful life) as a function of ripple current load (I_A/I_R) and ambient temperature.
I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz, 105 °C

Table 5 Multiplier of ripple current I_R as a function of frequency

FREQUENCY	I_R-MULTIPLIER		
	U_R = 16 and 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50 Hz	0.85	0.80	0.75
100 Hz	1.00	1.00	1.00
300 Hz	1.20	1.25	1.30
1000 Hz	1.30	1.40	1.50
3000 Hz	1.35	1.50	1.65
≥ 10000 Hz	1.40	1.60	1.80

Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE (quick reference)	SPECIFIC REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301, group C 3, 4.13	T_{amb} = 105 °C, U_R applied 1000 hours	$\Delta C/C \leq \pm 15$ % tan $\delta \leq 1.3$ x spec. limit $Z \leq 2$ x spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30 301, amendment 2640, sub clause 1.8.1	T_{amb} = 105 °C, U_R and I_R applied 1500 hours	$\Delta C/C \leq \pm 45$ % tan $\delta \leq 3$ x spec. limit $Z \leq 3$ x spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 105 °C, no voltage applied 500 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$\Delta C/C$, tan δ, Z: for requirements see Endurance test above $I_{L5} \leq 2$ x spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, non solid
- Radial leads, cylindrical aluminium case with safety vent insulated with a blue sleeve
- Charge and discharge proof
- Very long useful life, 3000/4000 h at 105 °C, high reliability
- High ripple current capability, low impedance

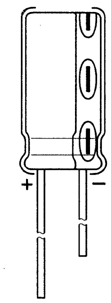


Fig.1 Component outline

APPLICATIONS

- Power supplies, EDP, telecommunication, industrial and audio-video
- Smoothing, filtering, buffering in SMPS
- Low PCB surface demand

QUICK REFERENCE DATA

Case size, øD_{nom} x L_{nom} in mm	10 x 12 to 18 x 40
Rated capacitance range, C_R	47 to 10000 µF
Tolerance on C_R	±20 %
Rated voltage range, U_R	6.3 to 63 V
Category temperature range	–40 to +105 °C
Endurance test at 105 °C	2000 hours
Useful life at 105 °C, case ø 10 and 12.5 mm case ø 16 and 18 mm	3000 hours 4000 hours
Useful life at 40 °C, 1.6 I_R applied case ø 10 and 12.5 mm case ø 16 and 18 mm	 200000 hours 260000 hours
Shelf life at 0 V, 105 °C	1000 hours
Basic specification	IEC 384-4, L.L. grade, CECC 30 300
Detail specification	DIN 41 259
Climatic category IEC 68	40/105/56
Climatic category DIN 40 040	GMF

Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (diameter x length in mm)

C_R µF	U_R (V) 6.3	10	16	25	35	40	50	63
47 *	For lower capacitance values see RLL 116 series							10 x 12
68							10 x 12	10 x 16
100 *						10 x 12	10 x 16	10 x 20
150					10 x 12	10 x 16	10 x 20	12.5 x 20
220 *			10 x 12		10 x 16	10 x 20	12.5 x 20	12.5 x 25
330		10 x 12	10 x 16		10 x 20	12.5 x 20	12.5 x 25	16 x 25
470 *	10 x 12	10 x 16	10 x 20		12.5 x 20	12.5 x 25		16 x 25
680	10 x 16	10 x 20	12.5 x 20		12.5 x 25		16 x 25	16 x 31
1000 *	10 x 20	12.5 x 20	12.5 x 25		16 x 25		16 x 31	18 x 35
1500	12.5 x 20	12.5 x 25	16 x 25		16 x 31	16 x 35	18 x 35	18 x 40
2200 *	12.5 x 25		16 x 25	16 x 31	18 x 35	18 x 35	18 x 40	
3300	16 x 25		16 x 31	18 x 35		18 x 40		
4700 *	16 x 31	16 x 35	18 x 35	18 x 40				
6800	16 x 35	18 x 35	18 x 40					
10000 *	18 x 35	18 x 40						

* E3 values = preferred values

MECHANICAL DATA Dimensions (in mm)

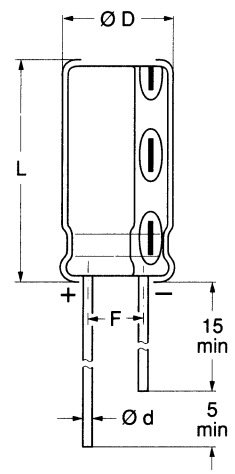


Fig. 2 **Form CA**, long leads; see Table 2 for dimensions.

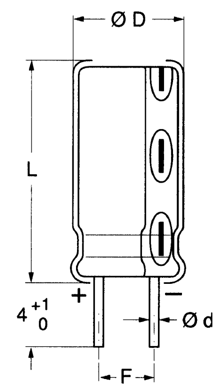


Fig. 3 **Form CB**, cut leads; see Table 2 for dimensions.

øD = 10 mm and 12.5 mm

øD = 16 mm

Fig. 4 **Form TR+**, case sizes up to ø16 x 31 taped on reel, positive leading. See Introduction for taping dimensions.

MARKING

The capacitors are marked with the following information:

- Rated capacitance value
- Tolerance on rated capacitance (M for ±20 %)
- Rated voltage
- Negative terminal identification
- Upper category temperature (105 °C)
- Group number (046)
- Code indicating factory of origin
- Name of manufacturer, PHILIPS
- Date code, in accordance with IEC 62

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Table 2 Dimensions (in mm)

CASE SIZE $øD_{nom} \times L_{nom}$	CASE CODE	RADIAL				MASS
		ød	$øD_{max}$	L_{max}	F ± 0,5	(g)
10 x 12	14	0.6	10.5	13.5	5.0	1.6
10 x 16	15	0.6	10.5	17.5	5.0	1.9
10 x 20	16	0.6	10.5	21.5	5.0	2.2
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0
16 x 25	19	0.8	16.5	27.0	7.5	8.0
16 x 31	20	0.8	16.5	33.0	7.5	9.0
16 x 35	21	0.8	16.5	37.0	7.5	11.5
18 x 35	22	0.8	18.5	37.0	7.5	14.5
18 x 40	23	0.8	18.5	42.0	7.5	16.0

PACKING

Capacitors of Form CA and Form CB are supplied in boxes, those of Form TR+ taped on reel. The numbers per box and per reel are given in Table 3.

Table 3 Packing quantities

CASE SIZE $øD_{nom} \times L_{nom}$	CASE CODE	NUMBER OF CAPACITORS		
		FORM CA per Box	FORM CB per Box	FORM TR+ per Reel
10 x 12	14	1000	1000	500
10 x 16	15	500	500	500
10 x 20	16	500	500	500
12.5 x 20	17	200	200	200
12.5 x 25	18	200	200	200
16 x 25	19	200	200	150
16 x 31	20	200	200	150
16 x 35	21	150	150	
18 x 35	22	100	100	
18 x 40	23	100	100	

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Table 4 apply at an ambient temperature of 20 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75 %.

C_R = rated capacitance at 100 Hz, tolerance ±20 %

I_R = rated RMS ripple current at 100 Hz, 105 °C

I_{L1} = max. leakage current after 1 minute at U_R

I_{L5} = max. leakage current after 5 minutes at U_R

tan δ = max. dissipation factor at 100 Hz

ESR = equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)

Z = max. impedance at 10 kHz or 100 kHz

Table 4 Electrical data

U_R	C_R	CASE SIZE øD_{nom} x L_{nom}	I_R	I_{L1}	I_{L5}	tan δ	ESR	Z at 10 kHz	Z at 100 kHz
(V)	(μF)	(mm)	(mA)	(μA)	(μA)		(Ω)	(Ω)	(Ω)
6.3	470	10 x 12	280	62	9	0.19	0.64		0.34
	680	10 x 16	350	89	12	0.19	0.44		0.24
	1000	10 x 20	460	130	16	0.19	0.30		0.16
	1500	12.5 x 20	580	190	22	0.21	0.22	0.16	
	2200	12.5 x 25	720	280	31	0.23	0.17	0.12	
	3300	16 x 25	940	420	45	0.25	0.12	0.08	
	4700	16 x 31	1200	600	62	0.27	0.09	0.06	
	6800	16 x 35	1400	860	89	0.31	0.07	0.05	
	10000	18 x 35	1500	1300	130	0.39	0.06	0.04	
10	330	10 x 12	270	69	10	0.15	0.65		0.39
	470	10 x 16	340	97	12	0.15	0.46		0.28
	680	10 x 20	440	140	17	0.15	0.32		0.19
	1000	12.5 x 20	590	200	23	0.15	0.21		0.13
	1500	12.5 x 25	740	300	33	0.17	0.16	0.12	
	4700	16 x 35	1400	940	97	0.23	0.07	0.04	
	6800	18 x 35	1600	1400	140	0.27	0.06	0.03	
	10000	18 x 40	1800	2000	200	0.35	0.05	0.03	
16	220	10 x 12	260	73	10	0.13	0.80		0.45
	330	10 x 16	330	110	14	0.13	0.53		0.30
	470	10 x 20	430	150	18	0.13	0.37		0.21
	680	12.5 x 20	560	220	25	0.13	0.26		0.15
	1000	12.5 x 25	740	320	35	0.13	0.18		0.10
	1500	16 x 25	920	480	51	0.15	0.14	0.09	
	2200	16 x 25	1100	710	73	0.17	0.10	0.06	
	3300	16 x 31	1300	1100	110	0.19	0.08	0.04	
	4700	18 x 35	1600	1500	150	0.21	0.06	0.03	
	6800	18 x 40	1900	2200	220	0.25	0.05	0.03	

ORDERING EXAMPLE

Electrolytic capacitors 2222 046 . . . . .
2200 µF/16 V, ±20 %
16 x 25, taped on reel, Form TR+
Catalogue number 2222 046 25222

Ordering information

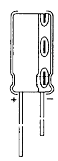
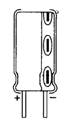
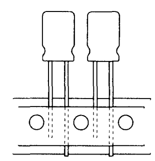
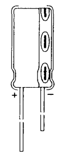
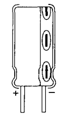
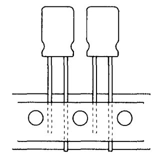
U_R	C_R	CASE SIZE $øD_{nom}$ x L_{nom}	CATALOGUE NUMBER 2222		
					
(V)	(µF)	(mm)	Form CA	Form CB	Form TR+
6.3	470	10 x 12	046 53471	046 63471	046 23471
	680	10 x 16	53681	63681	23681
	1000	10 x 20	53102	63102	23102
	1500	12.5 x 20	53152	63152	23152
	2200	12.5 x 25	53222	63222	23222
	3300	16 x 25	53332	63332	23332
	4700	16 x 31	53472	63472	23472
	6800	16 x 35	53682	63682	
	10000	18 x 35	53103	63103	
10	330	10 x 12	046 54331	046 64331	046 24331
	470	10 x 16	54471	64471	24471
	680	10 x 20	54681	64681	24681
	1000	12.5 x 20	54102	64102	24102
	1500	12.5 x 25	54152	64152	24152
	4700	16 x 35	54472	64472	
	6800	18 x 35	54682	64682	
	10000	18 x 40	54103	64103	
16	220	10 x 12	046 55221	046 65221	046 25221
	330	10 x 16	55331	65331	25331
	470	10 x 20	55471	65471	25471
	680	12.5 x 20	55681	65681	25681
	1000	12.5 x 25	55102	65102	25102
	1500	16 x 25	55152	65152	25152
	2200	16 x 25	55222	65222	25222
	3300	16 x 31	55332	65332	25332
	4700	18 x 35	55472	65472	
	6800	18 x 40	55682	65682	

Table 4 Electrical data (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom}$ x L_{nom} (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
25	2200	16 x 31	1200	1100	110	0.15	0.09	0.05	
	3300	18 x 35	1500	1700	170	0.17	0.07	0.03	
	4700	18 x 40	1800	2400	240	0.19	0.06	0.03	
35	150	10 x 12	250	110	14	0.10	0.90		0.40
	220	10 x 16	320	160	18	0.10	0.62		0.27
	330	10 x 20	420	230	26	0.10	0.41		0.18
	470	12.5 x 20	550	330	36	0.10	0.29		0.13
	680	12.5 x 25	720	480	51	0.10	0.20		0.09
	1000	16 x 25	940	700	73	0.10	0.14		0.06
	1500	16 x 31	1200	1100	110	0.11	0.10	0.06	
	2200	18 x 35	1500	1500	160	0.12	0.07	0.04	
40	100	10 x 12	220	83	11	0.09	1.20		0.55
	150	10 x 16	280	120	15	0.09	0.81		0.37
	220	10 x 20	360	180	21	0.09	0.55		0.25
	330	12.5 x 20	480	270	29	0.09	0.37		0.17
	470	12.5 x 25	630	380	41	0.09	0.26		0.12
	1500	16 x 35	1300	1200	120	0.10	0.09	0.05	
	2200	18 x 35	1600	1800	180	0.11	0.07	0.04	
	3300	18 x 40	1900	2600	270	0.12	0.05	0.03	
50	68	10 x 12	200	71	10	0.07	1.40		0.74
	100	10 x 16	260	100	13	0.07	0.95		0.50
	150	10 x 20	340	150	18	0.07	0.63		0.33
	220	12.5 x 20	450	220	25	0.07	0.43		0.23
	330	12.5 x 25	600	330	36	0.07	0.29		0.15
	680	16 x 25	940	680	71	0.07	0.14		0.07
	1000	16 x 31	1200	1000	100	0.07	0.10		0.05
	1500	18 x 35	1500	1500	150	0.08	0.07	0.04	
	2200	18 x 40	1800	2200	220	0.09	0.06	0.03	
63	47	10 x 12	180	62	9	0.06	1.90		0.85
	68	10 x 16	230	89	12	0.06	1.30		0.59
	100	10 x 20	290	130	16	0.06	0.91		0.40
	150	12.5 x 20	390	190	22	0.06	0.61		0.27
	220	12.5 x 25	520	280	31	0.06	0.41		0.18
	330	16 x 25	690	420	45	0.06	0.28		0.12
	470	16 x 25	840	600	62	0.06	0.19		0.09
	680	16 x 31	1100	860	89	0.06	0.13		0.06
	1000	18 x 35	1400	1300	130	0.06	0.09		0.04
	1500	18 x 40	1700	1900	190	0.07	0.07	0.04	

Ordering information (continued)

U_R (V)	C_R (μF)	CASE SIZE $øD_{nom} \times L_{nom}$ (mm)	CATALOGUE NUMBER 2222 ... .  Form CA	 Form CB	 Form TR+
25	2200	16 x 31	046 56222	046 66222	046 26222
	3300	18 x 35	56332	66332	
	4700	18 x 40	56472	66472	
35	150	10 x 12	046 50151	046 60151	046 20151
	220	10 x 16	50221	60221	20221
	330	10 x 20	50331	60331	20331
	470	12.5 x 20	50471	60471	20471
	680	12.5 x 25	50681	60681	20681
	1000	16 x 25	50102	60102	20102
	1500	16 x 31	50152	60152	20152
	2200	18 x 35	50222	60222	
40	100	10 x 12	046 57101	046 67101	046 27101
	150	10 x 16	57151	67151	27151
	220	10 x 20	57221	67221	27221
	330	12,5 x 20	57331	67331	27331
	470	12,5 x 25	57471	67471	27471
	1500	16 x 35	57152	67152	
	2200	18 x 35	57222	67222	
	3300	18 x 40	57332	67332	
50	68	10 x 12	046 51689	046 61689	046 21689
	100	10 x 16	51101	61101	21101
	150	10 x 20	51151	61151	21151
	220	12,5 x 20	51221	61221	21221
	330	12.5 x 25	51331	61331	21331
	680	16 x 25	51681	61681	21681
	1000	16 x 31	51102	61102	21102
	1500	18 x 35	51152	61152	
	2200	18 x 40	51222	61222	
63	47	10 x 12	046 58479	046 68479	046 28479
	68	10 x 16	58689	68689	28689
	100	10 x 20	58101	68101	28101
	150	12.5 x 20	58151	68151	28151
	220	12.5 x 25	58221	68221	28221
	330	16 x 25	58331	68331	28331
	470	16 x 25	58471	68471	28471
	680	16 x 31	58681	68681	28681
	1000	18 x 35	58102	68102	
	1500	18 x 40	58152	68152	

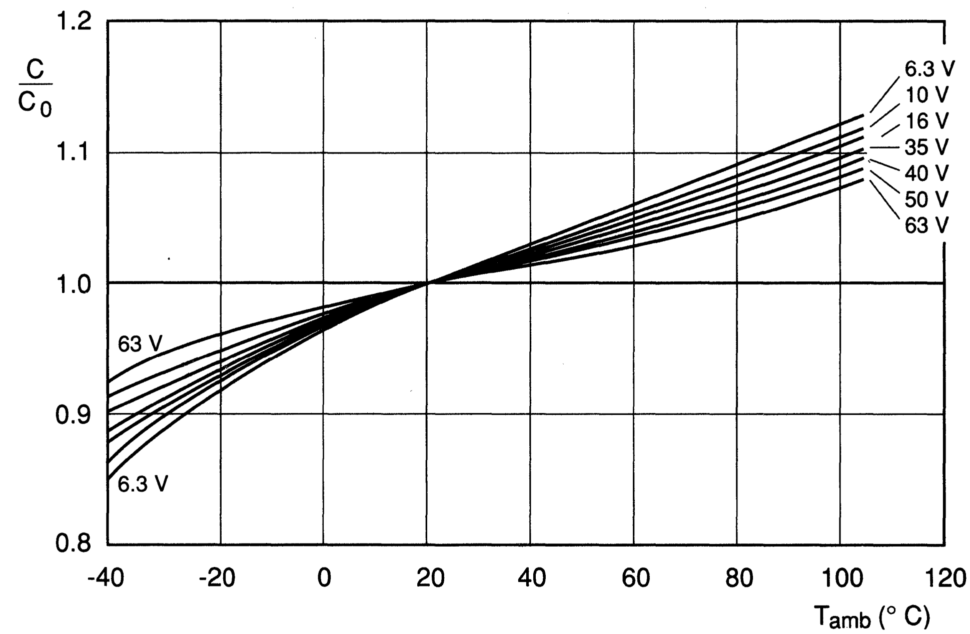


Fig. 5 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature;
C_0 = Capacitance at 20 °C, 100 Hz.

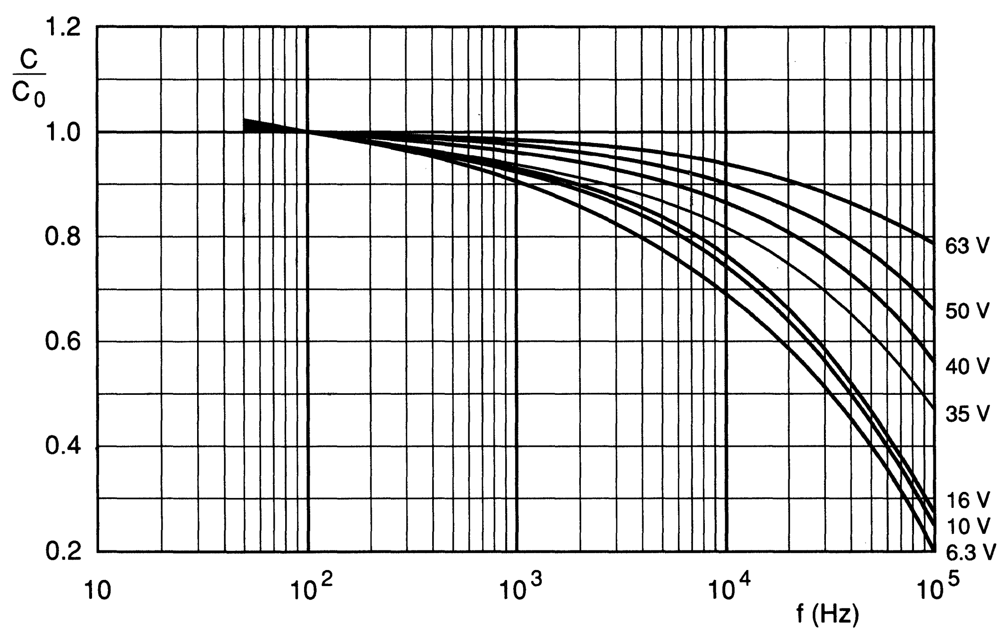


Fig. 6 Typical multiplier of capacitance (C/C_0) as a function of frequency;
C_0 = Capacitance at 20 °C, 100 Hz.

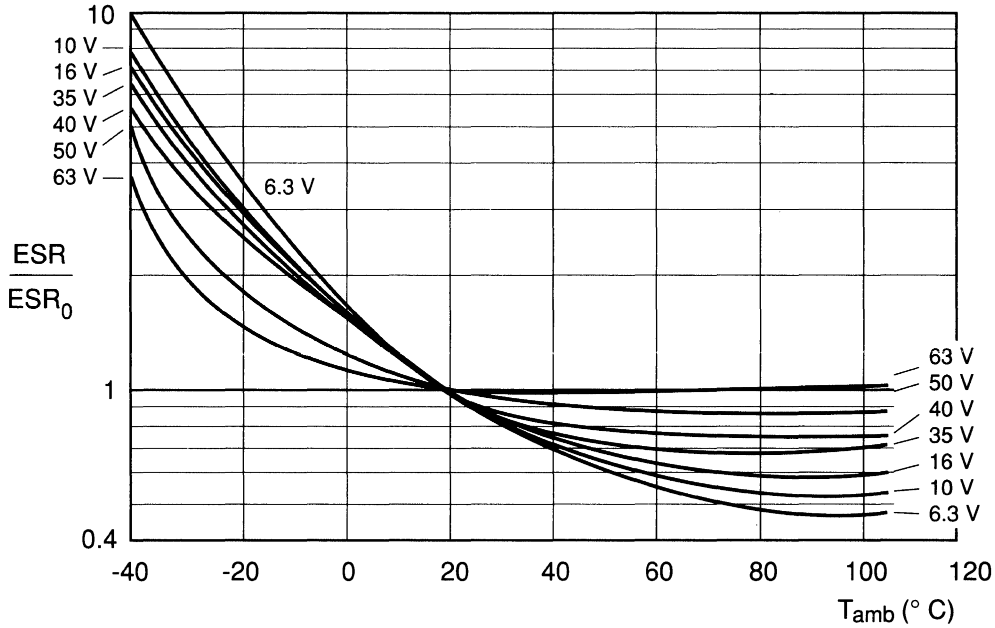


Fig. 7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; ESR_0 = typical ESR at 20 °C, 100 Hz.

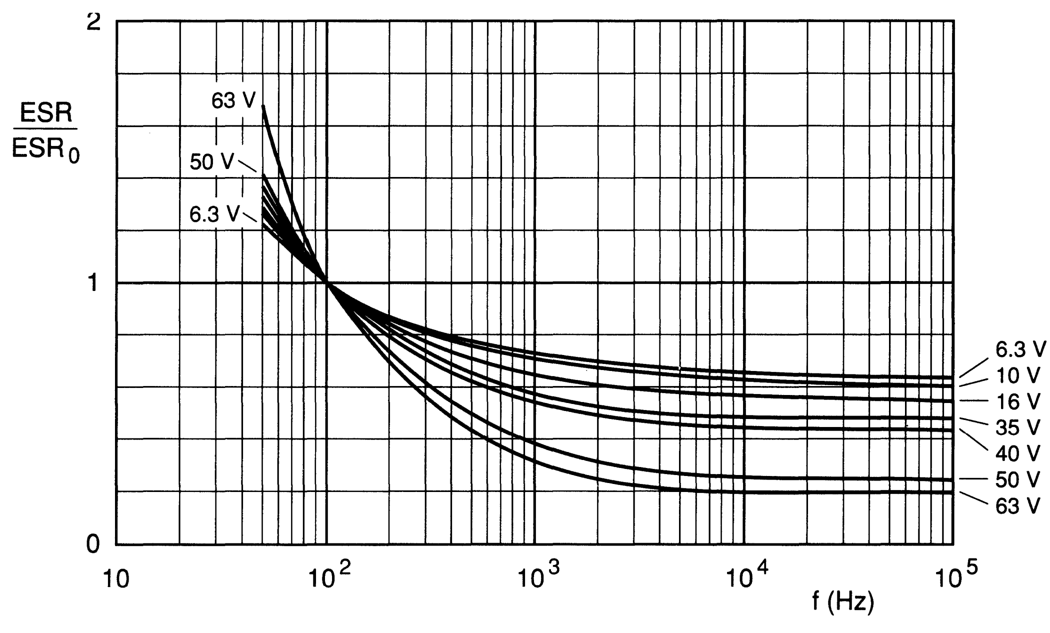


Fig. 8 Multiplier of ESR (ESR/ESR_0) as a function of frequency; ESR_0 = typical ESR at 20 °C, 100 Hz.

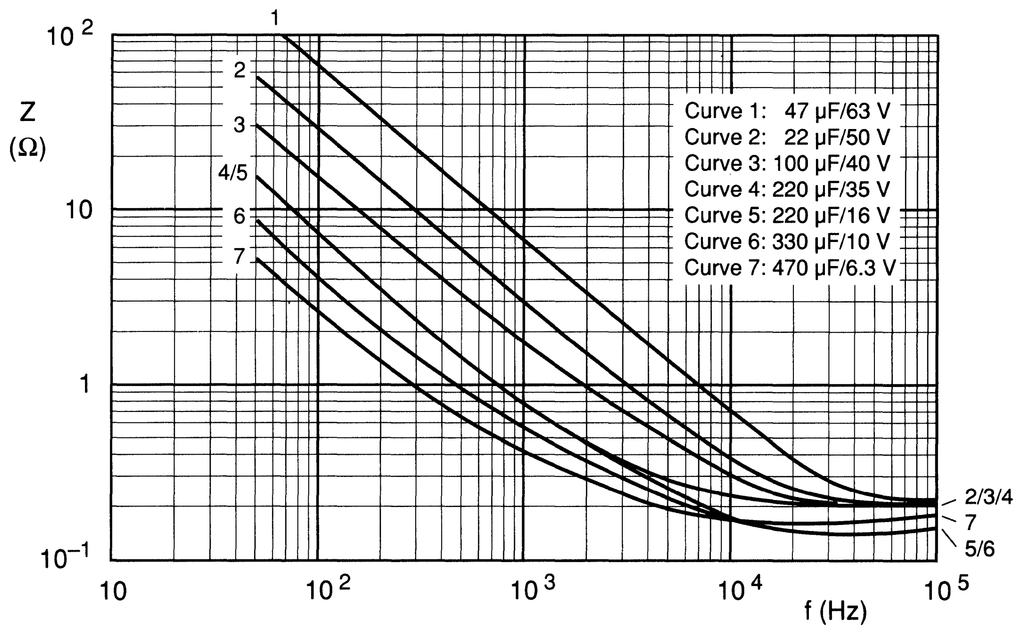


Fig. 9 Typical impedance at 20 °C as a function of frequency.

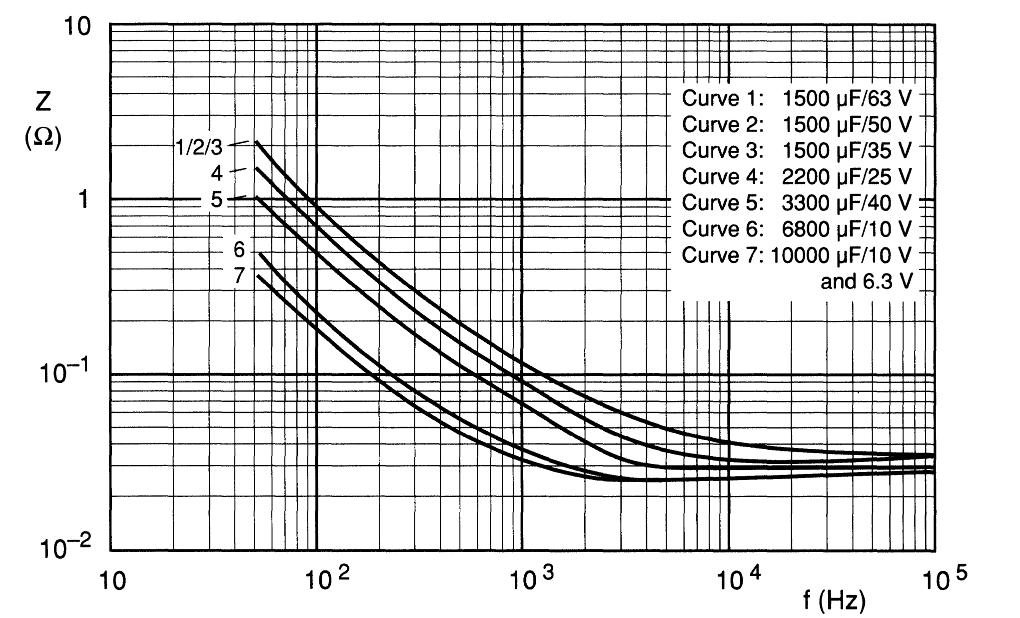


Fig. 10 Typical impedance at 20 °C as a function of frequency.

USEFUL LIFE

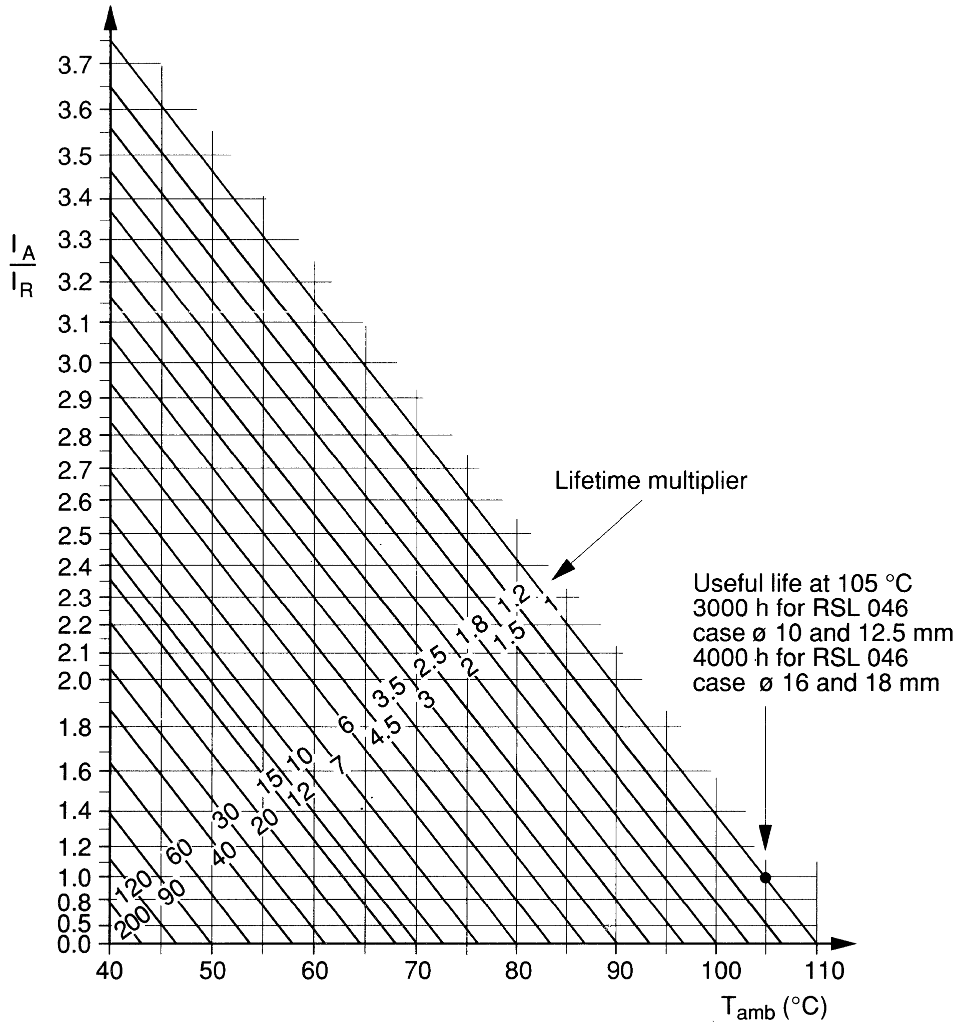


Fig. 11 Life expectancy (useful life) as a function of ripple current load (I_A/I_R) and ambient temperature.
I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz, 105 °C

Table 5 Multiplier of ripple current I_R as a function of frequency

FREQUENCY	I_R-MULTIPLIER		
	U_R = 6.3 to 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50 Hz	0.82	0.80	0.75
100 Hz	1.00	1.00	1.00
300 Hz	1.12	1.25	1.30
1000 Hz	1.20	1.40	1.50
3000 Hz	1.25	1.50	1.65
≥ 10000 Hz	1.30	1.60	1.80

Voltage

Surge voltage for short periods	$U_s \leq 1.15\ U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.02\ C_R\ U_R + 3\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R\ U_R + 3\ \mu A$

Equivalent series inductance (ESL)

Case diameter = 10 mm	typ. 16 nH
Case diameter ≥ 12,5 mm	typ. 18 nH

SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE	SPECIFIC REQUIREMENTS
Name of test	Reference	(quick reference)	
Endurance	IEC 384-4-1/ CECC 30 301 group C 3, 4.13	T_{amb} = 105 °C, U_R applied 2000 hours	U_R = 6.3 V: ΔC/C ≤ +15/–30 % U_R > 6.3 V: ΔC/C ≤ ±15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30 301 amendment 2640, sub clause 1.8.1	T_{amb} = 105 °C, U_R and I_R applied 3000 hours case ø 10 and 12.5 mm 4000 hours case ø 16 and 18 mm	U_R = 6.3 V: ΔC/C ≤ +45/–50 % U_R > 6.3 V: ΔC/C ≤ ±45 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 105 °C, no voltage applied 1000 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤ 2 x spec. limit

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NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non solid
- Radial leads, cylindrical aluminium case with safety vent insulated with a blue sleeve
- Charge and discharge proof
- Long useful life 1500 h/105 °C
- Miniaturized, high CU product per unit volume

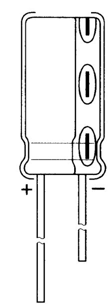

Fig.1 Component outline

APPLICATIONS

- EDB, telecommunication, industrial, automotive and audio-video
- Smoothing, filtering, buffering in SMPS, timing
- Portable and mobile equipment (small size, low mass)
- Low PCB surface demand

QUICK REFERENCE DATA

Case size, $øD_{nom}$ x L_{nom} in mm	10 x 12 to 18 x 40
Rated capacitance range, C_R	68 to 10000 μF
Tolerance on C_R	±20 %
Rated voltage range, U_R	16 to 63 V
Category temperature range	–40 to +105 °C
Endurance test at 105 °C	1000 hours
Useful life at 105 °C	1500 hours
Useful life at 40 °C, 1,3 I_R applied	150000 hours
Shelf life at 0 V, 105 °C	500 hours
Basic specification	IEC 384-4, L.L. grade, CECC 30 300
Detail specification	similar to DIN 41 259
Climatic category IEC 68	40/105/56
Climatic category DIN 40 040	GMF

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Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (diameter x length in mm)

C_R	U_R (V)					
μF	16	25	35	40	50	63
68	For lower capacitance values see RSP 036 series					10 x 12
100 *						10 x 12
150				10 x 12		10 x 16
220 *			10 x 12		10 x 16	10 x 20
330	10 x 12		10 x 16	10 x 20		12.5 x 20
470 *	10 x 12	10 x 16	10 x 20		12.5 x 20	12,5 x 25
680	10 x 16		12.5 x 20		12.5 x 25	16 x 25
1000 *	10 x 20	12.5 x 20	12.5 x 25		16 x 25	16 x 31
1500	12.5 x 20	12.5 x 25	16 x 25		16 x 35	18 x 35
2200 *	12.5 x 25	16 x 25	16 x 31	16 x 35	18 x 35	18 x 40
3300	16 x 25	16 x 31	■	18 x 35	18 x 40	
4700 *	16 x 31	■	18 x 40			
6800	16 x 35	18 x 40				
10000 *	18 x 40					

* E3 values = preferred values
■ 16 x 35 under consideration

MECHANICAL DATA Dimensions (in mm)

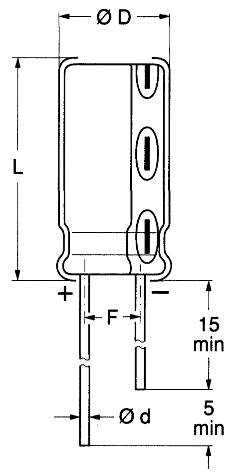


Fig. 2 **Form CA**, long leads; see Table 2 for dimensions.

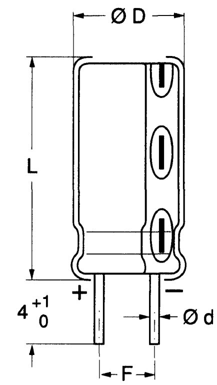
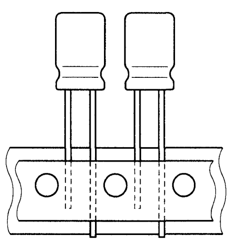
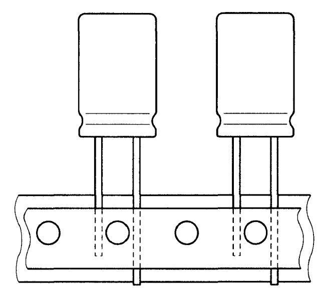


Fig. 3 **Form CB**, cut leads; see Table 2 for dimensions.



øD = 10 mm and 12.5 mm



øD = 16 mm

Fig. 4 **Form TR+**, case sizes up to ø16 x 31 taped on reel, positive leading. See Introduction for taping dimensions.

MARKING

The capacitors are marked with the following information:

- Rated capacitance value
- Tolerance on rated capacitance (M for ±20 %)
- Rated voltage
- Negative terminal identification
- Upper category temperature (105 °C)
- Group number (047)
- Code indicating factory of origin
- Name of manufacturer, PHILIPS
- Date code, in accordance with IEC 62

Table 2 Dimensions (in mm)

CASE SIZE $øD_{nom} \times L_{nom}$	CASE CODE	RADIAL				MASS (g)
		ød	$øD_{max}$	L_{max}	F ± 0,5	
10 x 12	14	0.6	10.5	13.5	5.0	1.6
10 x 16	15	0.6	10.5	17.5	5.0	1.9
10 x 20	16	0.6	10.5	21.5	5.0	2.2
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0
16 x 25	19	0.8	16.5	27.0	7.5	8.0
16 x 31	20	0.8	16.5	33.0	7.5	9.0
16 x 35	21	0.8	16.5	37.0	7.5	11.5
18 x 35	22	0.8	18.5	37.0	7.5	14.5
18 x 40	23	0.8	18.5	42.0	7.5	16.0

PACKING

Capacitors of Form CA and Form CB are supplied in boxes, those of Form TR+ taped on reel. The numbers per box and per reel are given in Table 3.

Table 3 Packing quantities

CASE SIZE $øD_{nom} \times L_{nom}$	CASE CODE	NUMBER OF CAPACITORS		
		FORM CA per Box	FORM CB per Box	FORM TR+ per Reel
10 x 12	14	1000	1000	500
10 x 16	15	500	500	500
10 x 20	16	500	500	500
12.5 x 20	17	200	200	200
12.5 x 25	18	200	200	200
16 x 25	19	200	200	150
16 x 31	20	200	200	150
16 x 35	21	150	150	
18 x 35	22	100	100	
18 x 40	23	100	100	

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Table 4 apply at an ambient temperature of 20 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75 %.

- C_R = rated capacitance at 100 Hz, tolerance ±20 %
- I_R = rated RMS ripple current at 100 Hz, 105 °C
- I_{L1} = max. leakage current after 1 minute at U_R
- I_{L5} = max. leakage current after 5 minutes at U_R
- tan δ = max. dissipation factor at 100 Hz
- ESR = equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
- Z = max. impedance at 10 kHz (100 kHz in preparation)

Table 4 Electrical data

U_R (V)	C_R (μF)	CASE SIZE øD$_{nom}$ x L$_{nom}$ (mm)	I_R (mA)	I_{L1} (μA)	I_{L5} (μA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
16	330	10 x 12	270	110	14	0.16	0.73	0.97	
	470	10 x 12	330	150	18	0.16	0.51	0.68	
	680	10 x 16	400	220	25	0.16	0.36	0.47	
	1000	10 x 20	540	320	35	0.16	0.24	0.32	
	1500	12.5 x 20	680	480	51	0.18	0.18	0.22	
	2200	12.5 x 25	830	710	73	0.20	0.14	0.15	
	3300	16 x 25	1100	1100	110	0.22	0.10	0.11	
	4700	16 x 31	1300	1500	150	0.24	0.08	0.08	
	6800	16 x 35	1600	2200	220	0.28	0.06	0.06	
	10000	18 x 40	1800	3200	320	0.36	0.05	0.05	
25	470	10 x 16	360	240	27	0.14	0.45	0.47	
	1000	12.5 x 20	630	500	53	0.14	0.21	0.22	
	1500	12.5 x 25	780	750	78	0.16	0.16	0.15	
	2200	16 x 25	990	1100	110	0.18	0.12	0.11	
	3300	16 x 31	1200	1700	170	0.20	0.09	0.07	
	6800	18 x 40	1700	3400	340	0.26	0.06	0.04	
35	220	10 x 12	270	160	18	0.12	0.83	0.68	
	330	10 x 16	350	230	26	0.12	0.55	0.45	
	470	10 x 20	450	330	36	0.12	0.39	0.32	
	680	12.5 x 20	580	480	51	0.12	0.27	0.22	
	1000	12.5 x 25	780	700	73	0.12	0.18	0.15	
	1500	16 x 25	970	1100	110	0.14	0.14	0.10	
	2200	16 x 31	1200	1500	160	0.16	0.11	0.07	
	4700	18 x 40	1800	3300	330	0.20	0.06	0.04	

ORDERING EXAMPLE

Electrolytic capacitors 2222 047 . . . . .

1000 µF/35 V, ±20 %

12.5 x 25, taped on reel, Form TR+

Catalogue number 2222 047 20102

Ordering information

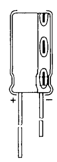
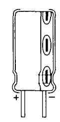
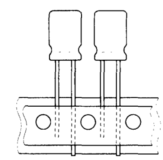
U_R (V)	C_R (µF)	CASE SIZE $øD_{nom}$ x L_{nom} (mm)	CATALOGUE NUMBER 2222 ... .  Form CA	 Form CB	 Form TR+
16	330	10 x 12	047 55331	047 65331	047 25331
	470	10 x 12	55471	65471	25471
	680	10 x 16	55681	65681	25681
	1000	10 x 20	55102	65102	25102
	1500	12.5 x 20	55152	65152	25152
	2200	12.5 x 25	55222	65222	25222
	3300	16 x 25	55332	65332	25332
	4700	16 x 31	55472	65472	25472
	6800	16 x 35	55682	65682	
	10000	18 x 40	55103	65103	
25	470	10 x 16	047 56471	047 66471	047 26471
	1000	12.5 x 20	56102	66102	26102
	1500	12.5 x 25	56152	66152	26152
	2200	16 x 25	56222	66222	26222
	3300	16 x 31	56332	66332	26332
	6800	18 x 40	56682	66682	
35	220	10 x 12	047 50221	047 60221	047 20221
	330	10 x 16	50331	60331	20331
	470	10 x 20	50471	60471	20471
	680	12.5 x 20	50681	60681	20681
	1000	12.5 x 25	50102	60102	20102
	1500	16 x 25	50152	60152	20152
	2200	16 x 31	50222	60222	20222
	4700	18 x 40	50472	60472	

Table 4 Electrical data (continued)

U_R (V)	C_R (µF)	CASE SIZE øD_{nom} x L_{nom} (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
40	150	10 x 12	230	120	15	0.12	1.20	0.87	
	330	10 x 20	380	270	29	0.12	0.55	0.39	
	2200	16 x 35	1200	1800	180	0.16	0.11	0.06	
	3300	18 x 35	1500	2600	270	0.18	0.08	0.04	
50	220	10 x 16	310	220	25	0.10	0.69	0.43	
	470	12.5 x 20	540	470	50	0.10	0.32	0.20	
	680	12.5 x 25	710	680	71	0.10	0.22	0.14	
	1000	16 x 25	940	1000	100	0.10	0.15	0.10	
	1500	16 x 35	1200	1500	150	0.12	0.12	0.07	
	2200	18 x 35	1400	2200	220	0.14	0.10	0.05	
	3300	18 x 40	1600	3300	330	0.16	0.07	0.03	
63	68	10 x 12	180	89	12	0.09	2.00	1.20	
	100	10 x 12	210	130	16	0.09	1.40	0.80	
	150	10 x 16	270	190	22	0.09	0.91	0.53	
	220	10 x 20	350	280	31	0.09	0.62	0.36	
	330	12.5 x 20	470	420	45	0.09	0.41	0.24	
	470	12.5 x 25	620	600	62	0.09	0.29	0.17	
	680	16 x 25	810	860	89	0.09	0.20	0.12	
	1000	16 x 31	1100	1300	130	0.09	0.14	0.08	
	1500	18 x 35	1300	1900	190	0.11	0.11	0.06	
	2200	18 x 40	1500	2800	280	0.13	0.09	0.04	

Voltage

Surge voltage for short periods	$U_s \leq 1.15\ U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.02\ C_R\ U_R + 3\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R\ U_R + 3\ \mu A$

Equivalent series inductance (ESL)

Case diameter = 10 mm	typ. 16 nH
Case diameter ≥ 12,5 mm	typ. 18 nH

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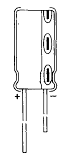
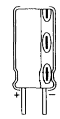
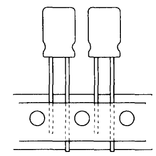
Ordering information (continued)

U_R	C_R	CASE SIZE $øD_{nom} \times L_{nom}$	CATALOGUE NUMBER 2222		
					
(V)	(µF)	(mm)	Form CA	Form CB	Form TR+
40	150	10 x 12	047 57151	047 67151	047 27151
	330	10 x 20	57331	67331	27331
	2200	16 x 35	57222	67222	
	3300	18 x 35	57332	67332	
50	220	10 x 16	047 51221	047 61221	047 21221
	470	12.5 x 20	51471	61471	21471
	680	12.5 x 25	51681	61681	21681
	1000	16 x 25	51102	61102	21102
	1500	16 x 35	51152	61152	
	2200	18 x 35	51222	61222	
	3300	18 x 40	51332	61332	
63	68	10 x 12	047 58689	047 68689	047 28689
	100	10 x 12	58101	68101	28101
	150	10 x 16	58151	68151	28151
	220	10 x 20	58221	68221	28221
	330	12.5 x 20	58331	68331	28331
	470	12.5 x 25	58471	68471	28471
	680	16 x 25	58681	68681	28681
	1000	16 x 31	58102	68102	28102
	1500	18 x 35	58152	68152	
	2200	18 x 40	58222	68222	

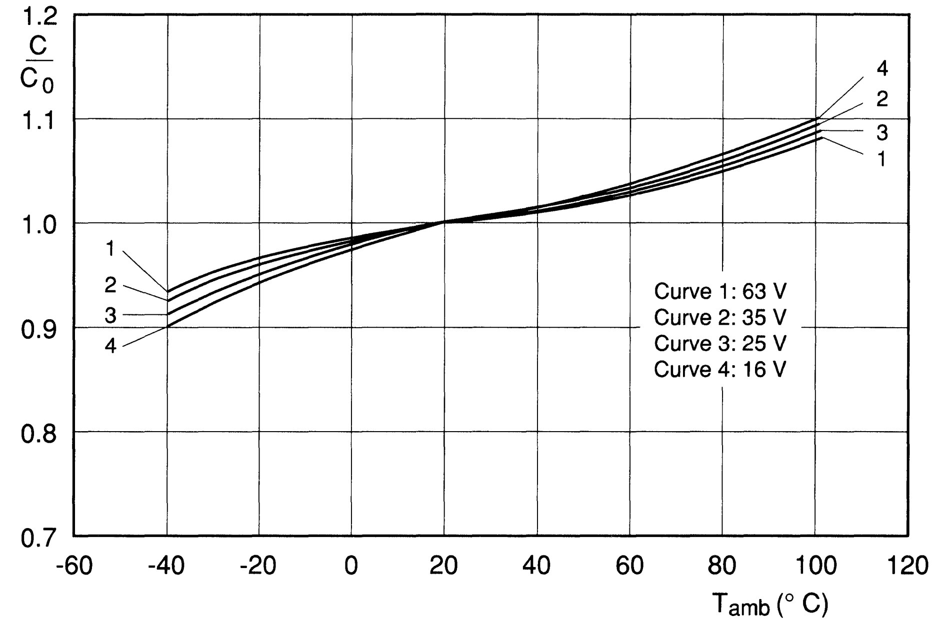


Fig. 5 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature;
C_0 = Capacitance at 20 °C, 100 Hz.

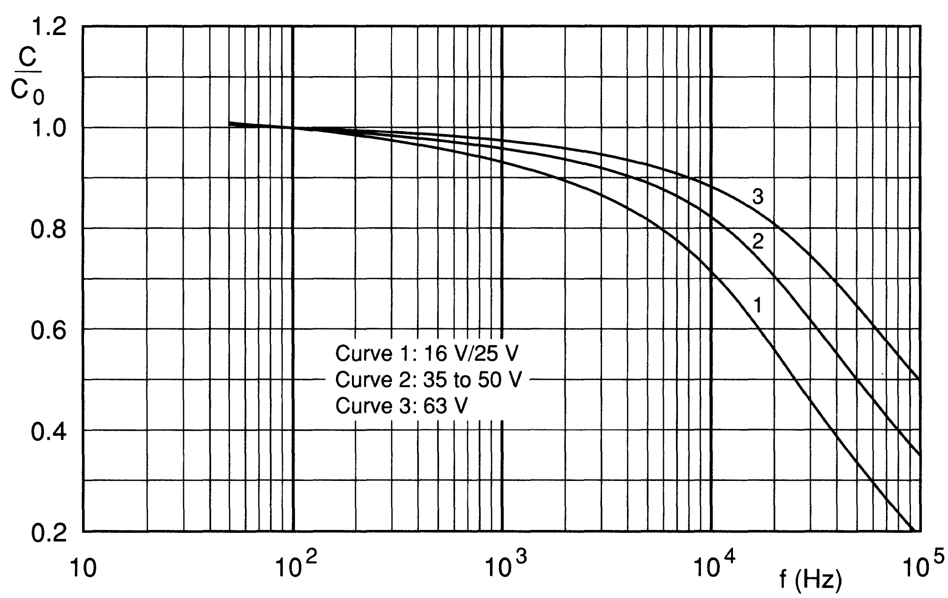


Fig. 6 Typical multiplier of capacitance (C/C_0) as a function of frequency;
C_0 = Capacitance at 20 °C, 100 Hz.

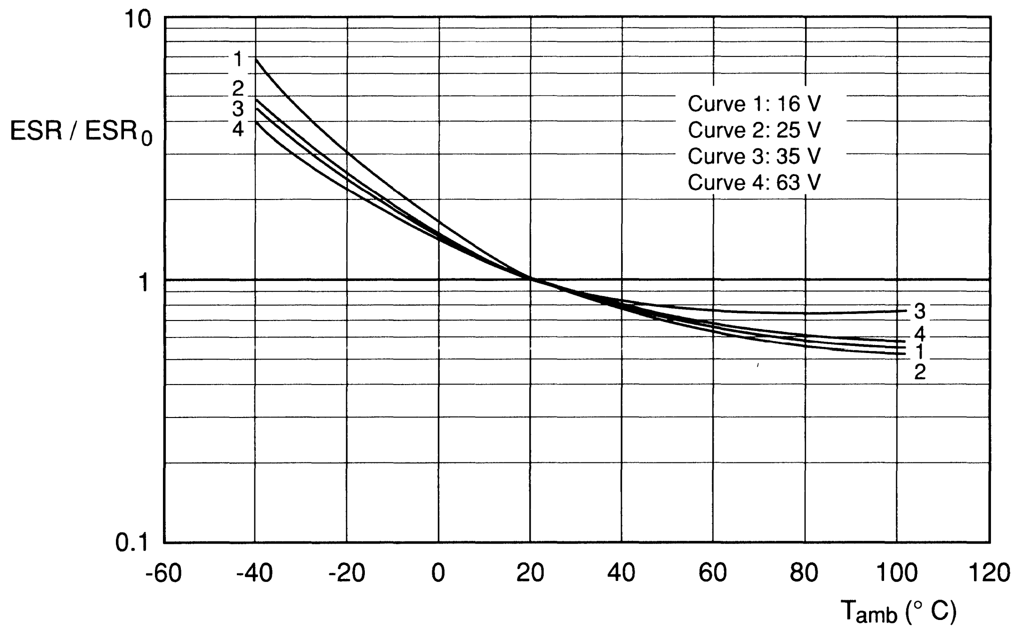


Fig. 7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; ESR_0 = typical ESR at 20 °C, 100 Hz.

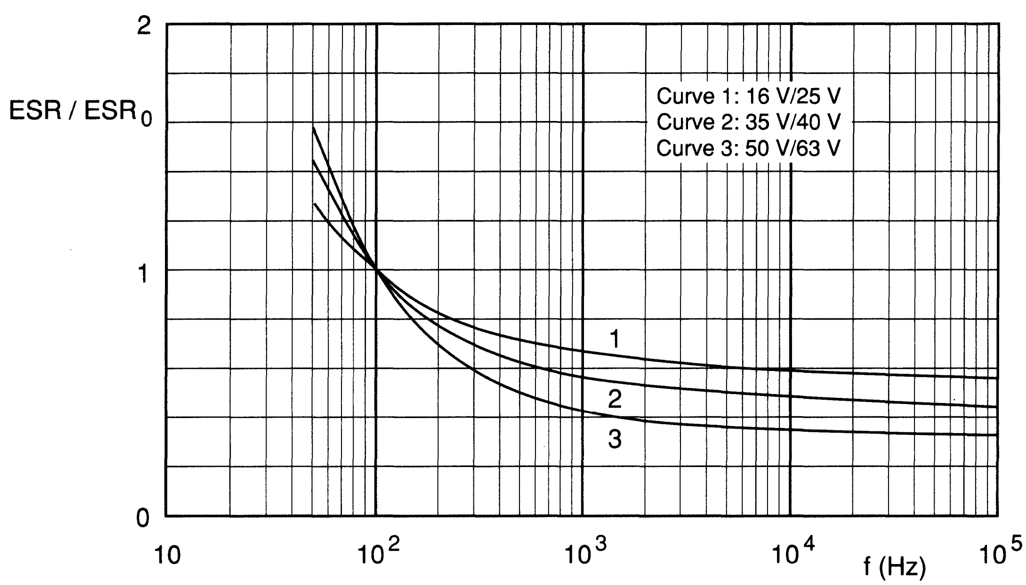


Fig. 8 Multiplier of ESR (ESR/ESR_0) as a function of frequency; ESR_0 = typical ESR at 20 °C, 100 Hz.

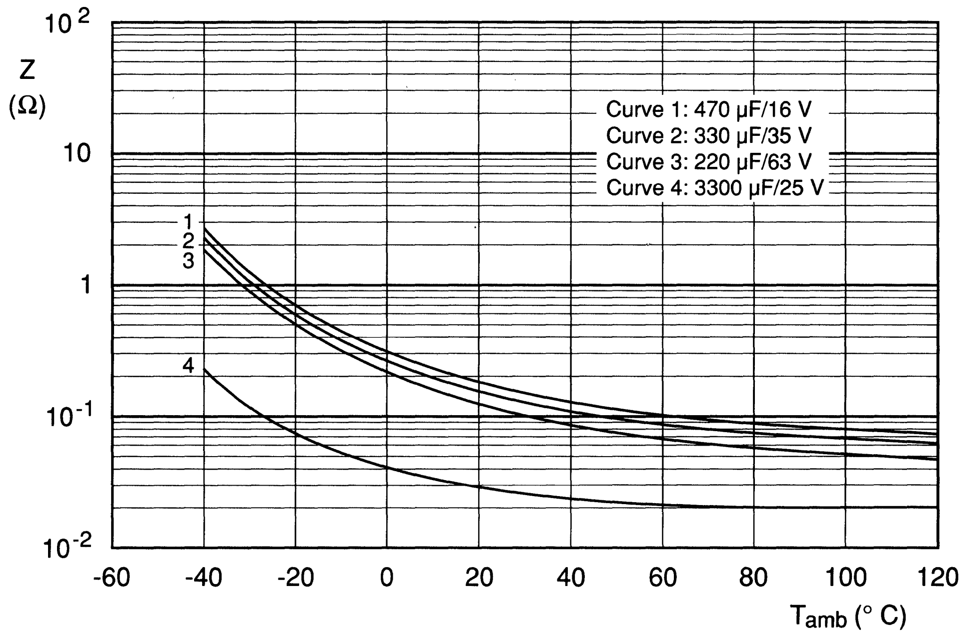


Fig. 9 Typical impedance at 10 kHz as a function of ambient temperature.

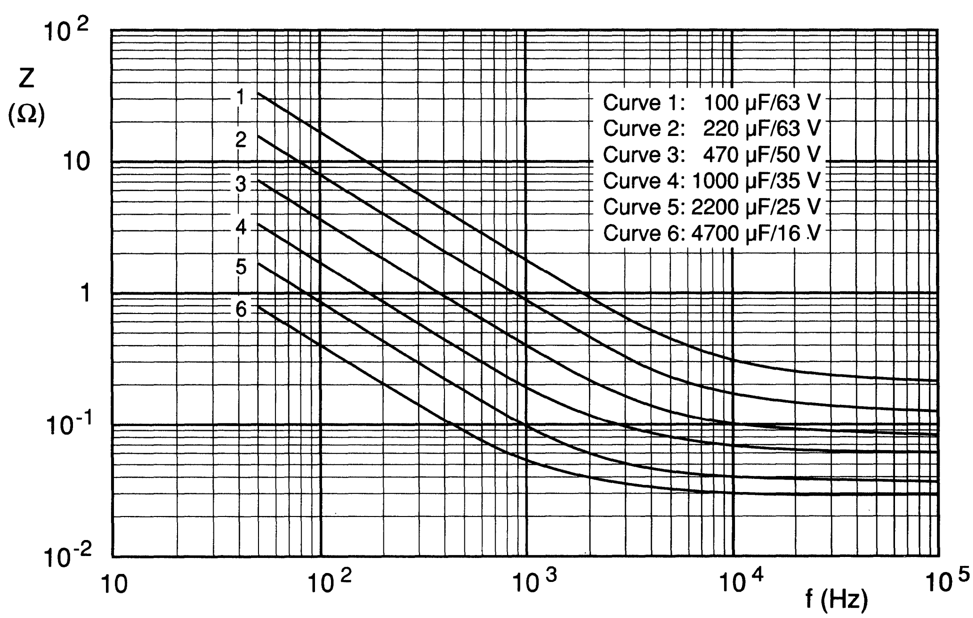


Fig. 10 Typical impedance at 20 °C as a function of frequency.

USEFUL LIFE

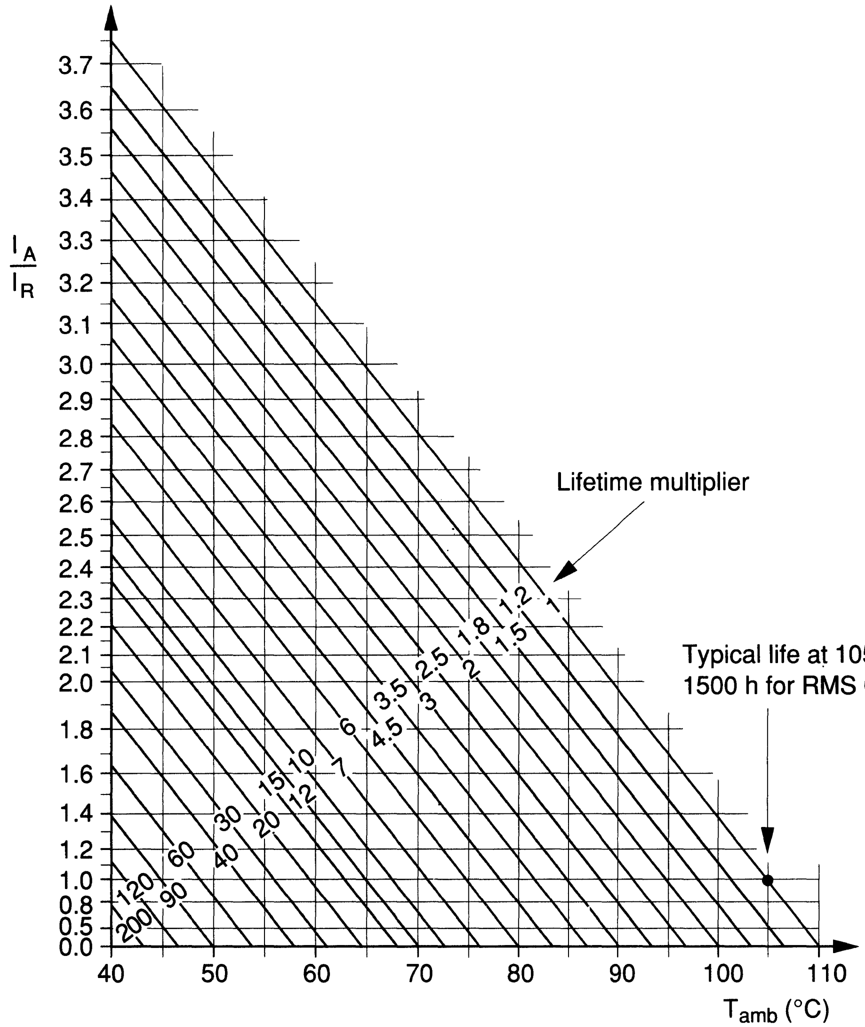


Fig. 11 Life expectancy (useful life) as a function of ripple current load (I_A/I_R) and ambient temperature.
I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz, 105 °C

Table 5 Multiplier of ripple current I_R as a function of frequency

FREQUENCY	I_R-MULTIPLIER		
	U_R = 16 and 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50 Hz	0.95	0.85	0.80
100 Hz	1.00	1.00	1.00
300 Hz	1.07	1.20	1.25
1000 Hz	1.12	1.30	1.40
3000 Hz	1.15	1.35	1.50
≥ 10000 Hz	1.20	1.40	1.60

SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE (quick reference)	SPECIFIC REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-1/ CECC 30 301, group C 3, 4.13	T_{amb} = 105 °C, U_R applied 1000 hours	$\Delta C/C \leq \pm 15$ % tan $\delta \leq 1.3$ x spec. limit $Z \leq 2$ x spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30 301, amendment 2640, sub clause 1.8.1	T_{amb} = 105 °C, U_R and I_R applied 1500 hours	$\Delta C/C \leq \pm 45$ % tan $\delta \leq 3$ x spec. limit $Z \leq 3$ x spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 105 °C, no voltage applied 500 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$\Delta C/C$, tan δ, Z: for requirements see Endurance test above $I_{L5} \leq 2$ x spec. limit

NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non solid
- Radial leads, cylindrical aluminium case with safety vent insulated with a blue sleeve
- Charge and discharge proof
- Miniaturized, high CU product per unit volume
- Very long useful life, 3000/4000 h at 105 °C, high reliability

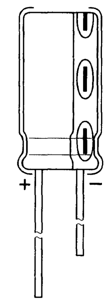


Fig.1 Component outline

APPLICATIONS

- EDP, telecommunication, industrial, automotive and audio-video
- Smoothing, filtering, buffering in SMPS, timing
- Portable and mobile equipment (small size, low mass)
- Low PCB surface demand

QUICK REFERENCE DATA

Case size, øD_{nom} x L_{nom} in mm	10 x 12 to 18 x 40
Rated capacitance range, C_R	68 to 15000 µF
Tolerance on C_R	±20 %
Rated voltage range, U_R	6.3 to 63 V
Category temperature range	–40 to +105 °C
Endurance test at 105 °C	2000 hours
Useful life at 105 °C, case ø 10 and 12.5 mm case ø 16 and 18 mm	3000 hours 4000 hours
Useful life at 40 °C, 1.6 I_R applied case ø 10 and 12.5 mm case ø 16 and 18 mm	 200000 hours 260000 hours
Shelf life at 0 V, 105 °C	1000 hours
Basic specification	IEC 384-4, L.L. grade, CECC 30 300
Detail specification	similar to DIN 41 259 (reduced dimensions)
Climatic category IEC 68	40/105/56
Climatic category DIN 40 040	GMF

Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (diameter x length in mm)

C_R µF	U_R (V) 6.3	10	16	25	35	40	50	63
68	For lower capacitance values see RLL 116 series							10 x 12
100 *								10 x 12
150						10 x 12		10 x 16
220 *					10 x 12		10 x 16	10 x 20
330			10 x 12		10 x 16	10 x 20		12.5 x 20
470 *			10 x 12	10 x 16	10 x 20		12.5 x 20	12.5 x 25
680		10 x 12	10 x 16		12.5 x 20		12.5 x 25	16 x 25
1000 *		10 x 16	10 x 20	12.5 x 20	12.5 x 25		16 x 25	16 x 31
1500	10 x 20		12.5 x 20	12.5 x 25	16 x 25		16 x 35	18 x 35
2200 *		12.5 x 20	12.5 x 25	16 x 25	16 x 31	16 x 35	18 x 35	18 x 40
3300		12.5 x 25	16 x 25	16 x 31	18 x 35	18 x 35	18 x 40	
4700 *		16 x 25	16 x 31	18 x 35	18 x 40			
6800	16 x 25	16 x 31	16 x 35	18 x 40				
10000 *	16 x 35	18 x 35	18 x 40					
15000	18 x 40							

* E3 values = preferred values

MECHANICAL DATA Dimensions (in mm)

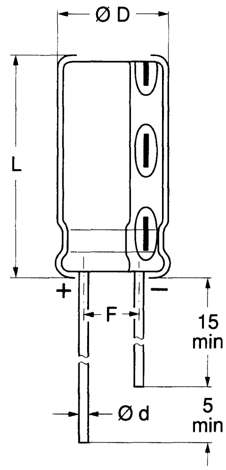


Fig. 2 **Form CA**, long leads; see Table 2 for dimensions.

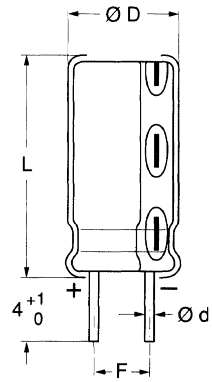


Fig. 3 **Form CB**, cut leads; see Table 2 for dimensions.

øD = 10 mm and 12.5 mm

øD = 16 mm

Fig. 4 **Form TR+**, case sizes up to ø16 x 31 taped on reel, positive leading. See Introduction for taping dimensions.

MARKING

The capacitors are marked with the following information:

- Rated capacitance value
- Tolerance on rated capacitance (M for ±20 %)
- Rated voltage
- Negative terminal identification
- Upper category temperature (105 °C)
- Group number (048)
- Code indicating factory of origin
- Name of manufacturer, PHILIPS
- Date code, in accordance with IEC 62

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Table 2 Dimensions (in mm)

CASE SIZE $øD_{nom} \times L_{nom}$	CASE CODE	RADIAL				MASS (g)
		ød	$øD_{max}$	L_{max}	**F ± 0,5**	
10 x 12	14	0.6	10.5	13.5	5.0	1.6
10 x 16	15	0.6	10.5	17.5	5.0	1.9
10 x 20	16	0.6	10.5	21.5	5.0	2.2
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0
16 x 25	19	0.8	16.5	27.0	7.5	8.0
16 x 31	20	0.8	16.5	33.0	7.5	9.0
16 x 35	21	0.8	16.5	37.0	7.5	11.5
18 x 35	22	0.8	18.5	37.0	7.5	14.5
18 x 40	23	0.8	18.5	42.0	7.5	16.0

PACKING

Capacitors of Form CA and Form CB are supplied in boxes, those of Form TR+ taped on reel. The numbers per box and per reel are given in Table 3.

Table 3 Packing quantities

CASE SIZE $øD_{nom} \times L_{nom}$	CASE CODE	NUMBER OF CAPACITORS		
		FORM CA per Box	**FORM CB per Box**	**FORM TR+ per Reel**
10 x 12	14	1000	1000	500
10 x 16	15	500	500	500
10 x 20	16	500	500	500
12.5 x 20	17	200	200	200
12.5 x 25	18	200	200	200
16 x 25	19	200	200	150
16 x 31	20	200	200	150
16 x 35	21	150	150	
18 x 35	22	100	100	
18 x 40	23	100	100	

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Table 4 apply at an ambient temperature of 20 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75 %.

- C_R = rated capacitance at 100 Hz, tolerance ±20 %
- I_R = rated RMS ripple current at 100 Hz, 105 °C
- I_{L1} = max. leakage current after 1 minute at U_R
- I_{L5} = max. leakage current after 5 minutes at U_R
- tan δ = max. dissipation factor at 100 Hz
- ESR = equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
- Z = max. impedance at 10 kHz (100 kHz in preparation)

Table 4 Electrical data

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom} \times L_{nom}$ (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
6.3	1500	10 x 20	500	190	22	0.26	0.28	0.41	
	6800	16 x 25	1200	860	89	0.36	0.08	0.11	
	10000	16 x 35	1500	1300	130	0.44	0.07	0.09	
	15000	18 x 40	1800	1900	190	0.54	0.06	0.07	
10	680	10 x 12	340	140	17	0.20	0.47	0.66	
	1000	10 x 16	430	200	23	0.20	0.32	0.45	
	2200	12.5 x 20	700	440	47	0.24	0.17	0.22	
	3300	12.5 x 25	870	660	69	0.26	0.13	0.15	
	4700	16 x 25	1100	940	97	0.28	0.10	0.11	
	6800	16 x 31	1400	1400	140	0.32	0.07	0.09	
	10000	18 x 35	1600	2000	200	0.40	0.06	0.07	
16	330	10 x 12	280	110	14	0.16	0.69	0.97	
	470	10 x 12	330	150	18	0.16	0.49	0.68	
	680	10 x 16	420	220	25	0.16	0.34	0.47	
	1000	10 x 20	550	320	35	0.16	0.23	0.32	
	1500	12.5 x 20	700	480	51	0.18	0.17	0.22	
	2200	12.5 x 25	870	710	73	0.20	0.13	0.15	
	3300	16 x 25	1100	1100	110	0.22	0.10	0.11	
	4700	16 x 31	1400	1500	150	0.24	0.07	0.08	
	6800	16 x 35	1600	2200	220	0.28	0.06	0.06	
	10000	18 x 40	1800	3200	320	0.36	0.05	0.05	

ORDERING EXAMPLE

Electrolytic capacitors 2222 048 . . . . .

2200 µF/16 V, ±20 %

12.5 x 25, taped on reel, Form TR+

Catalogue number 2222 048 25222

Ordering information

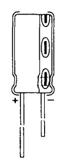
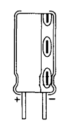
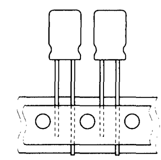
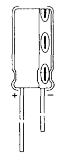
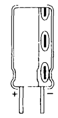
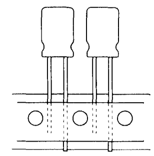
U_R	C_R	CASE SIZE $øD_{nom}$ x L_{nom}	CATALOGUE NUMBER 2222		
					
V	µF	mm	Form CA	Form CB	Form TR+
6.3	1500	10 x 20	048 53152	048 63152	048 23152
	6800	16 x 25	53682	63682	23682
	10000	16 x 35	53103	63103	
	15000	18 x 40	53153	63153	
10	680	10 x 12	048 54681	048 64681	048 24681
	1000	10 x 16	54102	64102	24102
	2200	12.5 x 20	54222	64222	24222
	3300	12.5 x 25	54332	64332	24332
	4700	16 x 25	54472	64472	24472
	6800	16 x 31	54682	64682	24682
	10000	18 x 35	54103	64103	
16	330	10 x 12	048 55331	048 65331	048 25331
	470	10 x 12	55471	65471	25471
	680	10 x 16	55681	65681	25681
	1000	10 x 20	55102	65102	25102
	1500	12.5 x 20	55152	65152	25152
	2200	12.5 x 25	55222	65222	25222
	3300	16 x 25	55332	65332	25332
	4700	16 x 31	55472	65472	25472
	6800	16 x 35	55682	65682	
	10000	18 x 40	55103	65103	

Table 4 Electrical data (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom} \times L_{nom}$ (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
25	470	10 x 16	370	240	27	0.14	0.43	0.47	
	1000	12.5 x 20	640	500	53	0.14	0.20	0.22	
	1500	12.5 x 25	810	750	78	0.16	0.15	0.15	
	2200	16 x 25	990	1100	110	0.18	0.12	0.11	
	3300	16 x 31	1300	1700	170	0.20	0.09	0.07	
	4700	18 x 35	1500	2400	240	0.22	0.07	0.06	
	6800	18 x 40	1800	3400	340	0.26	0.06	0.04	
35	220	10 x 12	260	160	18	0.12	0.78	0.68	
	330	10 x 16	340	230	26	0.12	0.52	0.45	
	470	10 x 20	430	330	36	0.12	0.37	0.32	
	680	12.5 x 20	570	480	51	0.12	0.25	0.22	
	1000	12.5 x 25	760	700	73	0.12	0.17	0.15	
	1500	16 x 25	950	1100	110	0.14	0.13	0.10	
	2200	16 x 31	1200	1500	160	0.16	0.10	0.07	
	3300	18 x 35	1400	2300	230	0.18	0.08	0.05	
	4700	18 x 40	1700	3300	330	0.20	0.06	0.04	
40	150	10 x 12	220	120	15	0.12	1.10	0.87	
	330	10 x 20	360	270	29	0.12	0.52	0.39	
	2200	16 x 35	1200	1800	180	0.16	0.10	0.06	
	3300	18 x 35	1400	2600	270	0.18	0.08	0.04	
50	220	10 x 16	300	220	25	0.10	0.65	0.43	
	470	12.5 x 20	520	470	50	0.10	0.30	0.20	
	680	12.5 x 25	680	680	71	0.10	0.21	0.14	
	1000	16 x 25	920	1000	100	0.10	0.14	0.10	
	1500	16 x 35	1200	1500	150	0.12	0.11	0.07	
	2200	18 x 35	1300	2200	220	0.14	0.09	0.05	
	3300	18 x 40	1600	3300	330	0.16	0.07	0.03	
63	68	10 x 12	170	89	12	0.09	1.90	1.20	
	100	10 x 12	200	130	16	0.09	1.30	0.80	
	150	10 x 16	260	190	22	0.09	0.86	0.53	
	220	10 x 20	340	280	31	0.09	0.59	0.36	
	330	12.5 x 20	460	420	45	0.09	0.39	0.24	
	470	12.5 x 25	600	600	62	0.09	0.27	0.17	
	680	16 x 25	790	860	89	0.09	0.19	0.12	
	1000	16 x 31	1000	1300	130	0.09	0.13	0.08	
	1500	18 x 35	1200	1900	190	0.11	0.11	0.06	
	2200	18 x 40	1400	2800	280	0.13	0.09	0.04	

Ordering information (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom} \times L_{nom}$ (mm)	CATALOGUE NUMBER 2222 ... .  Form CA	 Form CB	 Form TR+
25	470	10 x 16	048 56471	048 66471	048 26471
	1000	12.5 x 20	56102	66102	26102
	1500	12.5 x 25	56152	66152	26152
	2200	16 x 25	56222	66222	26222
	3300	16 x 31	56332	66332	26332
	4700	18 x 35	56472	66472	
	6800	18 x 40	56682	66682	
35	220	10 x 12	048 50221	048 60221	048 20221
	330	10 x 16	50331	60331	20331
	470	10 x 20	50471	60471	20471
	680	12.5 x 20	50681	60681	20681
	1000	12.5 x 25	50102	60102	20102
	1500	16 x 25	50152	60152	20152
	2200	16 x 31	50222	60222	20222
	3300	18 x 35	50332	60332	
	4700	18 x 40	50472	60472	
40	150	10 x 12	048 57151	048 67151	048 27151
	330	10 x 20	57331	67331	27331
	2200	16 x 35	57222	67222	
	3300	18 x 35	57332	67332	
50	220	10 x 16	048 51221	048 61221	048 21221
	470	12,5 x 20	51471	61471	21471
	680	12.5 x 25	51681	61681	21681
	1000	16 x 25	51102	61102	21102
	1500	16 x 35	51152	61152	
	2200	18 x 35	51222	61222	
	3300	18 x 40	51332	61332	
63	68	10 x 12	048 58689	048 68689	048 28689
	100	10 x 12	58101	68101	28101
	150	10 x 16	58151	68151	28151
	220	10 x 20	58221	68221	28221
	330	12.5 x 20	58331	68331	28331
	470	12.5 x 25	58471	68471	28471
	680	16 x 25	58681	68681	28681
	1000	16 x 31	58102	68102	28102
	1500	18 x 35	58152	68152	
	2200	18 x 40	58222	68222	

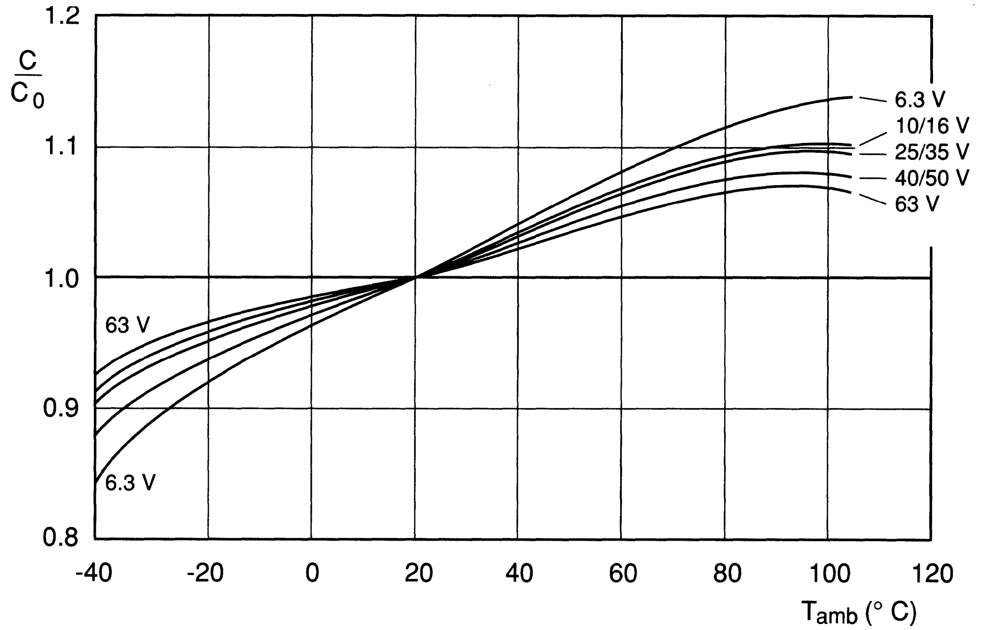


Fig. 5 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature; C_0 = Capacitance at 20 °C, 100 Hz.

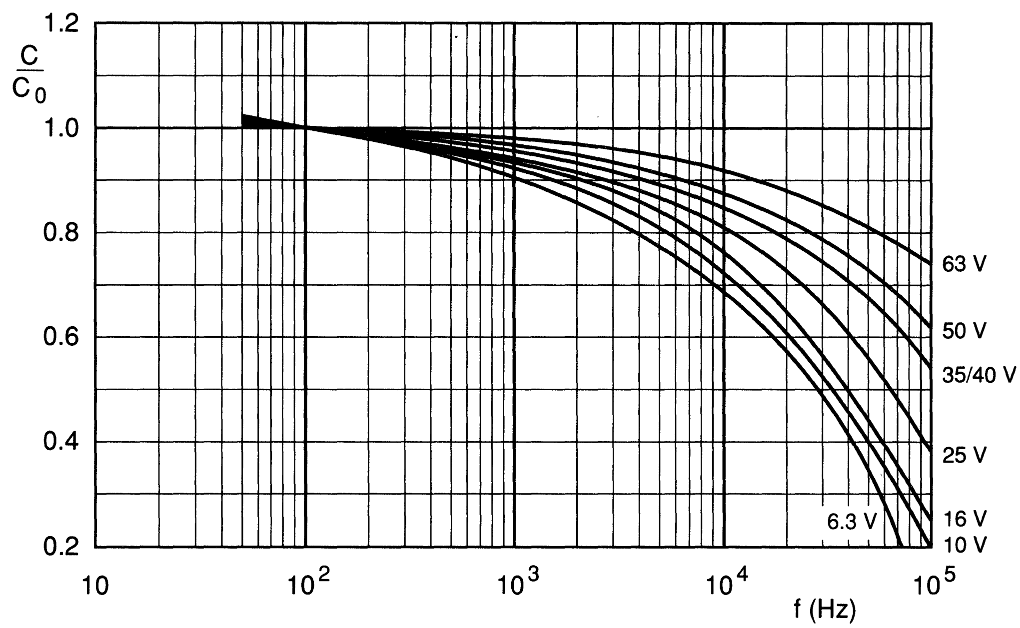


Fig. 6 Typical multiplier of capacitance (C/C_0) as a function of frequency; C_0 = Capacitance at 20 °C, 100 Hz.

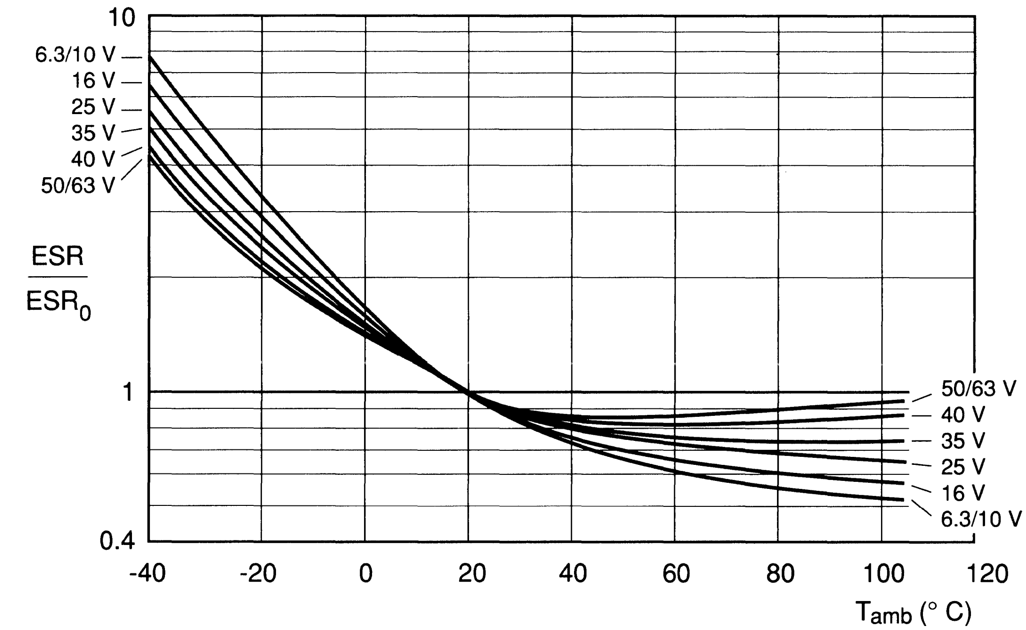


Fig. 7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; ESR_0 = typical ESR at 20 °C, 100 Hz.

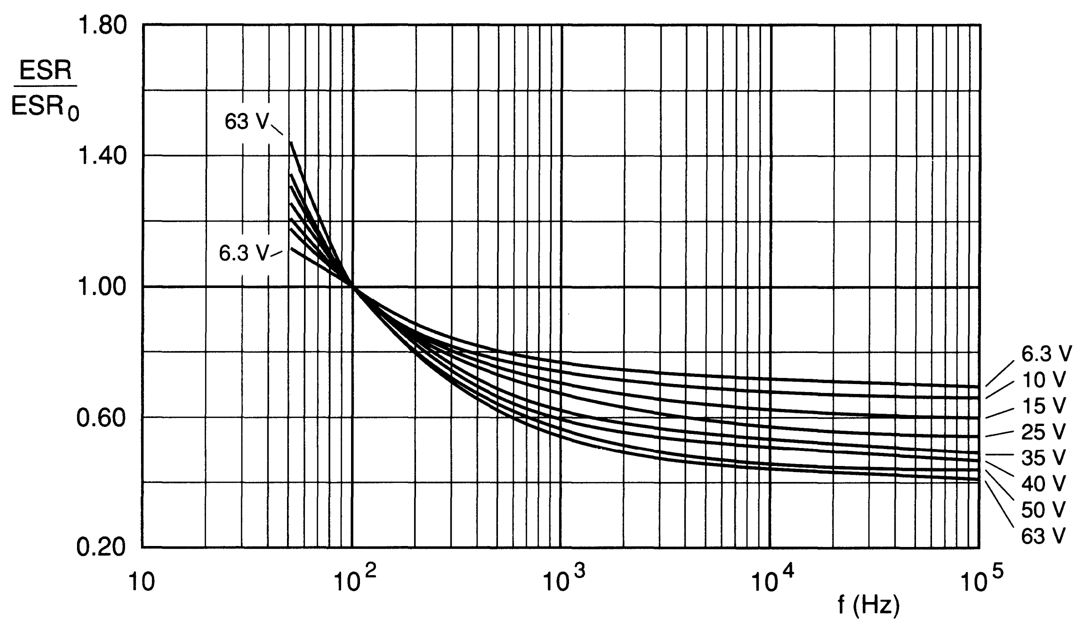


Fig. 8 Multiplier of ESR (ESR/ESR_0) as a function of frequency; ESR_0 = typical ESR at 20 °C, 100 Hz.

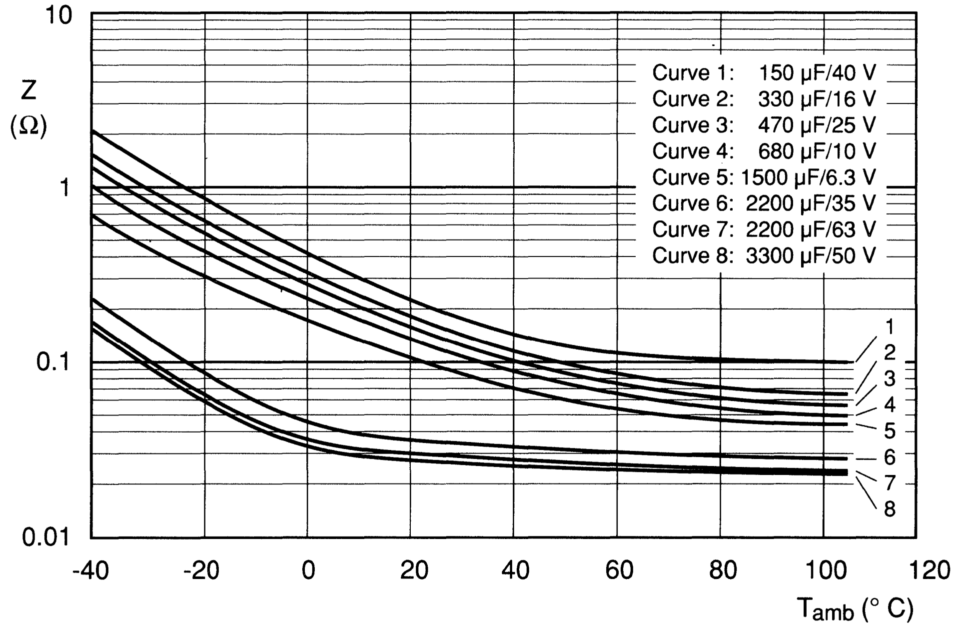


Fig. 9 Typical impedance at 10 kHz as a function of ambient temperature.

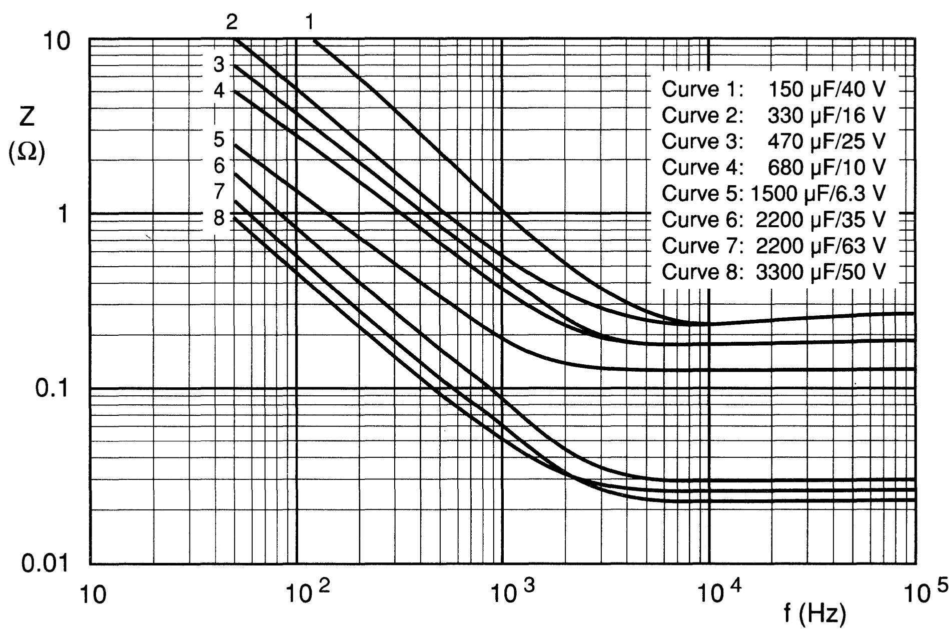


Fig. 10 Typical impedance at 20 °C as a function of frequency.

USEFUL LIFE

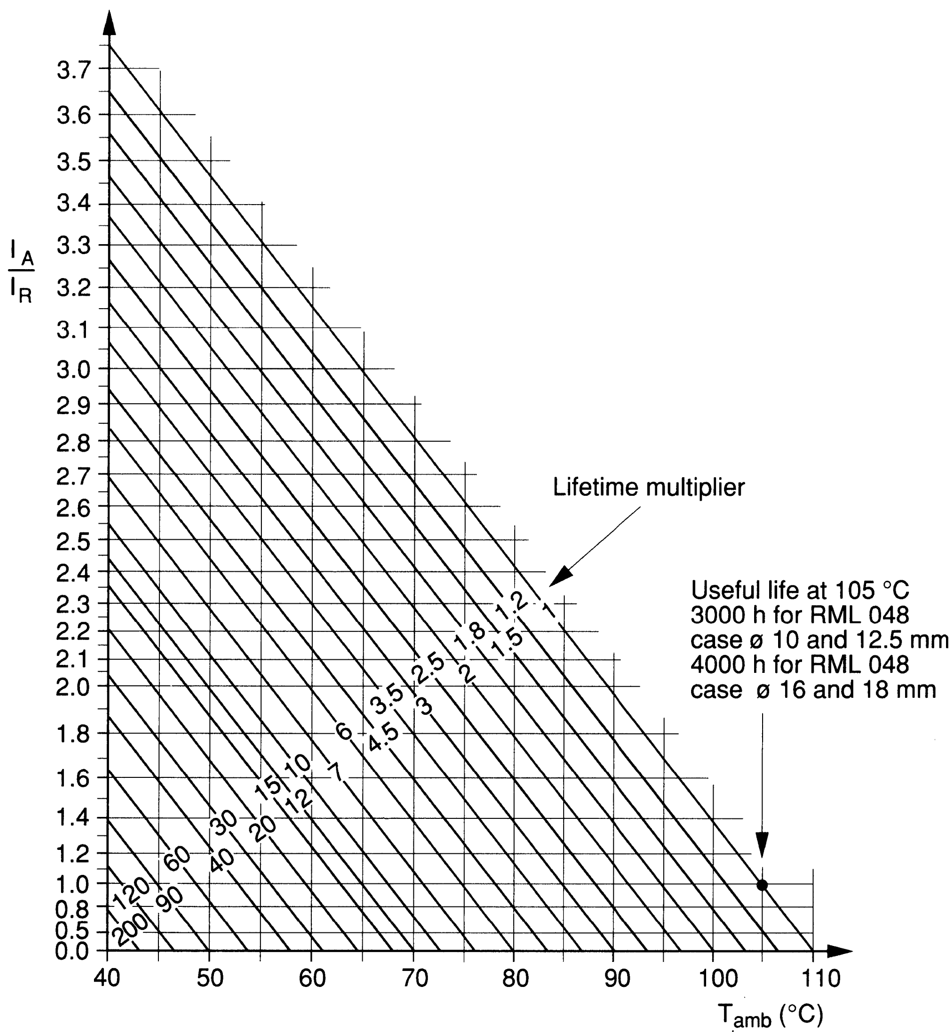


Fig. 11 Life expectancy (useful life) as a function of ripple current load (I_A/I_R) and ambient temperature.
I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz, 105 °C

Table 5 Multiplier of ripple current I_R as a function of frequency

FREQUENCY	I_R-MULTIPLIER		
	U_R = 6.3 to 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50 Hz	0.95	0.85	0.80
100 Hz	1.00	1.00	1.00
300 Hz	1.07	1.20	1.25
1000 Hz	1.12	1.30	1.40
3000 Hz	1.15	1.35	1.50
≥ 10000 Hz	1.20	1.40	1.60

Voltage

Surge voltage for short periods	$U_s \leq 1.15\ U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.02\ C_R\ U_R + 3\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R\ U_R + 3\ \mu A$

Equivalent series inductance (ESL)

Case diameter = 10 mm	typ. 16 nH
Case diameter ≥ 12,5 mm	typ. 18 nH

SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE (quick reference)	SPECIFIC REQUIREMENTS
Name of test	Reference		
Endurance	IEC 384-4-1/ CECC 30 301 group C 3, 4.13	T_{amb} = 105 °C, U_R applied 2000 hours	U_R = 6.3 V: ΔC/C ≤ +15/–30 % U_R > 6.3 V: ΔC/C ≤ ±15 % tan δ ≤ 1.3 x spec. limit Z ≤ 2 x spec. limit I_{L5} ≤ spec. limit
Useful life	CECC 30 301 amendment 2640, sub clause 1.8.1	T_{amb} = 105 °C, U_R and I_R applied 3000 hours case ø 10 and 12.5 mm 4000 hours case ø 16 and 18 mm	U_R = 6.3 V: ΔC/C ≤ +45/–50 % U_R > 6.3 V: ΔC/C ≤ ±45 % tan δ ≤ 3 x spec. limit Z ≤ 3 x spec. limit I_{L5} ≤ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 105 °C, no voltage applied 1000 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤ 2 x spec. limit

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NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, non-solid
- Radial leads, cylindrical aluminium case, all-insulated (light blue)
- Natural pitch 2.5 mm and 5 mm
- Charge and discharge proof
- Miniaturized, high CU-product per unit volume
- Long useful life: 2000 hours at 105 °C, high reliability.

APPLICATIONS

- Automotive, telecommunication, industrial and EDP
- Stand-by applications in audio and video equipment
- Coupling, decoupling, timing; smoothing, filtering and buffering in DC-DC converters
- Portable and mobile equipment (small size, low mass)
- Low surface demand on printed circuit board.

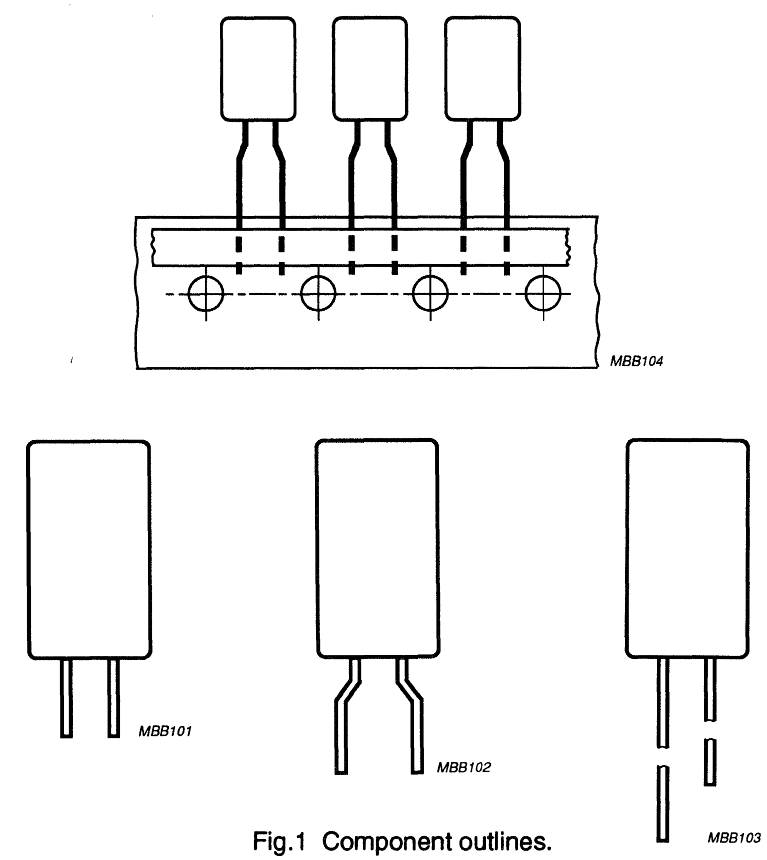

Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (∅ D_{nom} x L_{nom})	5 x 11 and 8.2 x 11 mm
Rated capacitance range, C_R	0.47 to 470 μF
Tolerance on C_R	±20%
Rated voltage range, U_R	6.3 to 100 V
Category temperature range	–55 to +105 °C
Endurance test at 105 °C	1500 hours
Endurance test at 85 °C	5000 hours
Useful life at 105 °C	2000 hours
Useful life at 40 °C, 1.3 I_R applied	200 000 hours
Shelf life at 0 V, 105 °C	1500 hours
Basic specification	IEC 384-4/CECC 30300, LL grade
Detail specification	IEC 384-4-1/CECC 30301 similar to DIN 41259 (with reduced dimensions)
Climatic category IEC 68 DIN 40040	 55/105/56 FMF

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Table 1 Selection chart for $C_R U_R$ and relevant nominal case sizes (**∅ D x L** in **mm**) * = preferred values

C_R (μF)	U_R (V)								
	6.3	**10**	**16**	**25**	**35**	**40**	**50**	**63**	**100**
0.47 *							5 x 11		
1.0 *							5 x 11		
1.5							5 x 11		
2.2 *							5 x 11		8.2 x 11
3.3							5 x 11		
4.7 *							5 x 11		8.2 x 11
6.8							5 x 11		
10 *							5 x 11 8.2 x 11		8.2 x 11
15							5 x 11		
22 *							5 x 11 8.2 x 11	8.2 x 11	
33					5 x 11	5 x 11	8.2 x 11		
47 *				5 x 11			8.2 x 11		
68			5 x 11				8.2 x 11		
100 *		5 x 11			8.2 x 11	8.2 x 11			
150	5 x 11			8.2 x 11					
220 *			8.2 x 11			For higher capacitance values see RSL 046 and RML 048 series			
330 *		8.2 x 11							
470 *	8.2 x 11								

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.

Table 2 Dimensions in mm; mass in g

CASE SIZE $\varnothing D_{nom} \times L_{nom}$	CASE CODE	$\varnothing$ d	$\varnothing D_{max}$	L_{max}	F ±0.5	APPROX. MASS	PACKING QUANTITIES		
							Form CA CB, CC	Form TR+ TR–, TN	Form TFA
5 x 11	11	0.5	5.5	12	2.5	0.4	1000	1000	2000
8.2 x 11	13	0.6	8.7	12	5	1.1	1000	500	1000

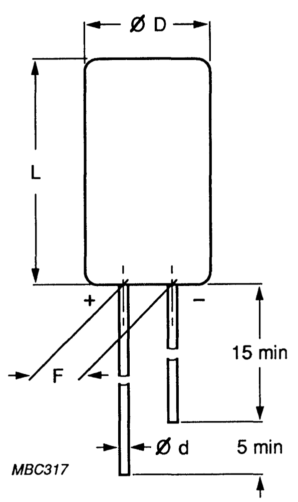

Fig.2 **Form CA**: Long leads.

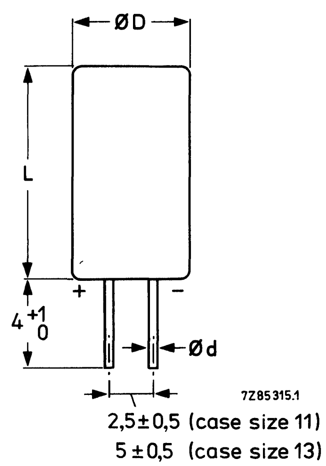

Fig.3 **Form CB**: Cut leads.

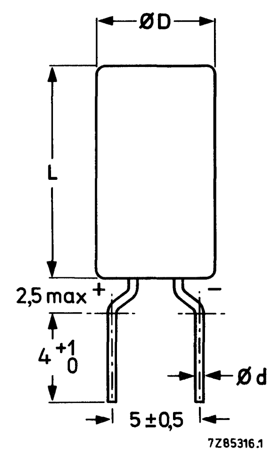

Fig.4 **Form CC**: Cut leads, formed; case size 5 x 11 only.

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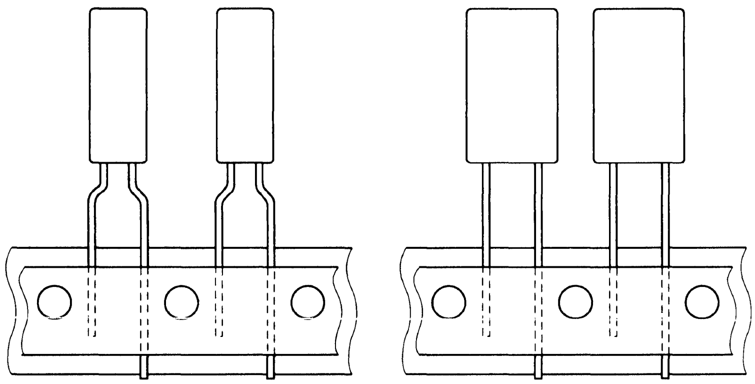
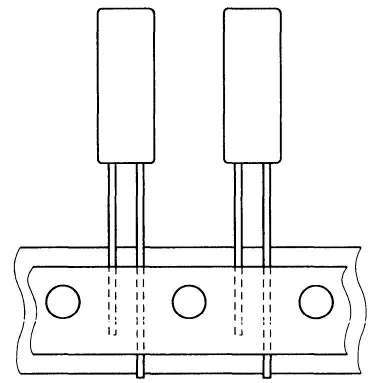
Tape dimensions are specified in chapter "PACKING",



Form TR+: Taped on reel, positive leading.
Form TR–: Taped on reel, negative leading.
Form TFA : Taped in box (ammopack).

Fig.5 Taped, pitch F = 5 mm; case sizes 5 x 11 and 8.2 x 11.



Form TN+: Taped on reel, positive leading.

Fig.6 Taped, pitch F = 2.5 mm; case size 5 x 11 only.

MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance in µF
- Tolerance on rated capacitance, code letter in accordance with IEC 62
- Rated voltage in V
- Group number (116)
- Grade indication (LL)
- Name of manufacturer (PHILIPS)
- Date code in accordance with IEC 62
- Code indicating factory of origin
- Minus-sign to identify the negative terminal.

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 3 apply at T_{amb} = 20 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	=	rated capacitance at 100 Hz, tolerance ± 20%
I_R	=	rated RMS ripple current at 100 Hz, 105 °C
I_{L1}	=	max. leakage current after 1 minute at U_R
I_{L5}	=	max. leakage current after 5 minutes at U_R
tan δ	=	max. dissipation factor at 100 Hz
ESR	=	equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	=	max. impedance at 10 kHz and 20, –25 or –40 °C.

Table 3 Electrical data

U_R (V)	C_R 100 Hz (μF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 105 °C (mA)	I_{L1} 1 min (μA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz 20 °C (Ω)	Z 10 kHz -25 °C (Ω)	Z 10 kHz –40 °C (Ω)
6.3	150	5 x 11	11	100	8.7	3.9	0.25	2.7	2	12	32
	470	8.2 x 11	13	230	21	6	0.25	0.8	0.64	3.8	10
10	100	5 x 11	11	95	9	4	0.2	3.2	2	12	32
	330	8.2 x 11	13	210	23	6.3	0.2	1.0	0.61	3.6	9.7
16	68	5 x 11	11	90	9.5	4.1	0.16	3.7	2.4	11	29
	220	8.2 x 11	13	200	24	6.5	0.16	1.2	0.73	3.4	9.1
25	47	5 x 11	11	80	10	4.2	0.14	4.7	2.6	12	32
	150	8.2 x 11	13	180	26	6.8	0.14	1.5	0.8	3.7	10
35	33	5 x 11	11	75	9.9	4.2	0.12	5.8	2.7	12	33
	100	8.2 x 11	13	160	24	6.5	0.12	1.9	0.9	4	11
40	33	5 x 11	11	75	10.9	4.3	0.12	5.8	2.7	12	33
	100	8.2 x 11	13	160	27	7	0.12	1.9	0.9	4	11

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ORDERING INFORMATION

Ordering Example

Electrolytic Capacitor 2222 116 . . . . .

100 µF/40 V, ±20%

Case size 8.2 x 11; Form TR+

Catalogue number: 2222 116 27101.

Table 4

U_R (V)	C_R 100 Hz (µF)	CATALOGUE NUMBER 2222						
		BULK PACKING			TAPED ON REEL			TAPED IN BOX F = 5 mm
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR–	F = 2.5 mm positive leading Form TN+	Form TFA
6.3	150	116 53151	116 83151	116 63151	116 23151	116 43151	116 13151	116 33151
	470	116 53471	116 63471	–	116 23471	116 43471	–	116 33471
10	100	116 54101	116 84101	116 64101	116 24101	116 44101	116 14101	116 34101
	330	116 54331	116 64331	–	116 24331	116 44331	–	116 34331
16	68	116 55689	116 85689	116 65689	116 25689	116 45689	116 15689	116 35689
	220	116 55221	116 65221	–	116 25221	116 45221	–	116 35221
25	47	116 56479	116 86479	116 66479	116 26479	116 46479	116 16479	116 36479
	150	116 56151	116 66151	–	116 26151	116 46151	–	116 36151
35	33	116 50339	116 80339	116 60339	116 20339	116 40339	116 10339	116 30339
	100	116 50101	116 60101	–	116 20101	116 40101	–	116 30101
40	33	116 57339	116 87339	116 67339	116 27339	116 47339	116 17339	116 37339
	100	116 57101	116 67101	–	116 27101	116 47101	–	116 37101

U_R (V)	C_R 100 Hz (µF)	NOMINAL CASE SIZE ∅ D x L (mm)	CASE CODE	I_R 105 °C (mA)	I_{L1} 1 min (µA)	I_{L5} 5 min (µA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 10 kHz 20 °C (Ω)	Z 10 kHz −25 °C (Ω)	Z 10 kHz −40 °C (Ω)
50	0.47	5 x 11	11	7	3.1	3	0.09	300	150	640	1900
	1.0	5 x 11	11	12	3.3	3.1	0.09	140	70	300	900
	1.5	5 x 11	11	16	3.5	3.1	0.09	95	47	200	600
	2.2	5 x 11	11	22	3.7	3.1	0.09	65	32	135	410
	3.3	5 x 11	11	26	4	3.2	0.09	43	21	91	270
	4.7	5 x 11	11	31	4.4	3.2	0.09	30	15	64	190
	6.8	5 x 11	11	38	5	3.3	0.09	21	10	44	130
	10	5 x 11	11	45	6	3.5	0.09	14	7	30	90
	10	8.2 x 11	13	100	6	3.5	0.05	8.0	3.6	14	40
	15	5 x 11	11	55	7.5	3.8	0.09	9.5	4.7	20	60
	22	5 x 11	11	70	9.6	4.1	0.09	6.5	3.2	13.5	41
	22	8.2 x 11	13	110	9.6	4.1	0.06	4.4	2.2	9.8	29
	33	8.2 x 11	13	120	13	4.7	0.09	4.3	2.1	9.1	27
	47	8.2 x 11	13	130	17	5.4	0.09	3.0	1.5	6.4	19
	68	8.2 x 11	13	150	23	6.4	0.09	2.1	1.0	4.4	13
63	22	8.2 x 11	13	90	11	4.4	0.08	5.8	3.5	22	65
100	2.2	8.2 x 11	13	35	4.3	3.2	0.06	43	18	80	190
	4.7	8.2 x 11	13	45	5.8	3.5	0.07	24	12	70	170
	10	8.2 x 11	13	60	9	4	0.08	13	4.5	28	70

U_R (V)	C_R 100 Hz (µF)	CATALOGUE NUMBER 2222						
		BULK PACKING			TAPED ON REEL			TAPED IN BOX F = 5 mm
		LONG LEADS Form CA	CUT LEADS Form CB	CUT LEADS FORMED Form CC	F = 5 mm positive leading Form TR+	F = 5 mm negative leading Form TR–	F = 2.5 mm positive leading Form TN+	Form TFA
50	0.47	116 51477	116 81477	116 61477	116 21477	116 41477	116 11477	116 31477
	1.0	116 51108	116 81108	116 61108	116 21108	116 41108	116 11108	116 31108
	1.5	116 51158	116 81158	116 61158	116 21158	116 41158	116 11158	116 31158
	2.2	116 51228	116 81228	116 61228	116 21228	116 41228	116 11228	116 31228
	3.3	116 51338	116 81338	116 61338	116 21338	116 41338	116 11338	116 31338
	4.7	116 51478	116 81478	116 61478	116 21478	116 41478	116 11478	116 31478
	6.8	116 51688	116 81688	116 61688	116 21688	116 41688	116 11688	116 31688
	10	116 51109	116 81109	116 61109	116 21109	116 41109	116 11109	116 31109
	10	116 90084	116 90085	–	116 90055	116 90016	–	116 90036
	15	116 51159	116 81159	116 61159	116 21159	116 41159	116 11159	116 31159
	22	116 51229	116 81229	116 61229	116 21229	116 41229	116 11229	116 31229
	22	116 90025	116 90086	–	116 90057	116 90018	–	116 90039
	33	116 51339	116 61339	–	116 21339	116 41339	–	116 31339
	47	116 51479	116 61479	–	116 21479	116 41479	–	116 31479
	68	116 51689	116 61689	–	116 21689	116 41689	–	116 31689
63	22	116 58229	116 68229	–	116 28229	116 48229	–	116 38229
100	2.2	116 59228	116 69228	–	116 29228	116 49228	–	116 39228
	4.7	116 59478	116 69478	–	116 29478	116 49478	–	116 39478
	10	116 59109	116 69109	–	116 29109	116 49109	–	116 39109

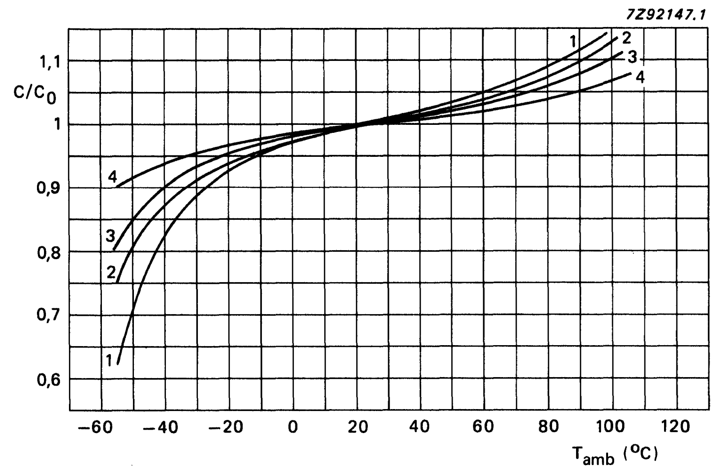
Voltage

Surge voltage for short periods	$U_s \leq 1.3\ U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.006\ C_R \times U_R + 3$ µA
After 5 minutes at U_R	$I_{L5} \leq 0.001\ C_R \times U_R + 3$ µA

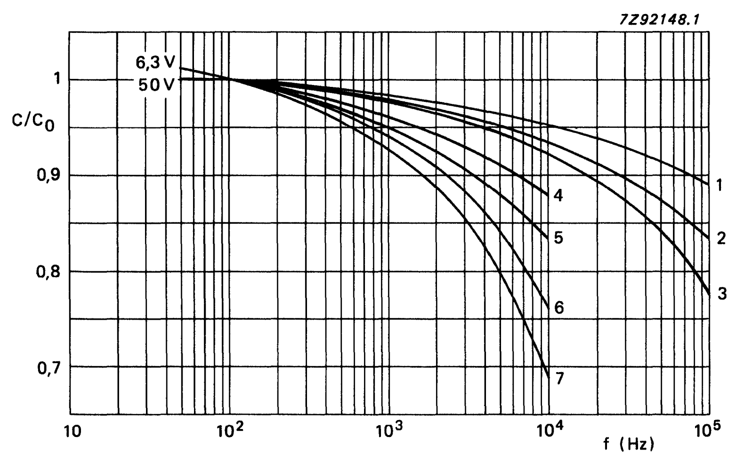
Capacitance (C)



Curve 1: 6.3 V
Curve 2: 10/16 V
Curve 3: 35/40 V and 63/100 V
Curve 4: 50 V.

C_o = capacitance at 20 °C, 100 Hz.

Fig.7 Multiplier of capacitance (C/C_o) as a function of ambient temperature.

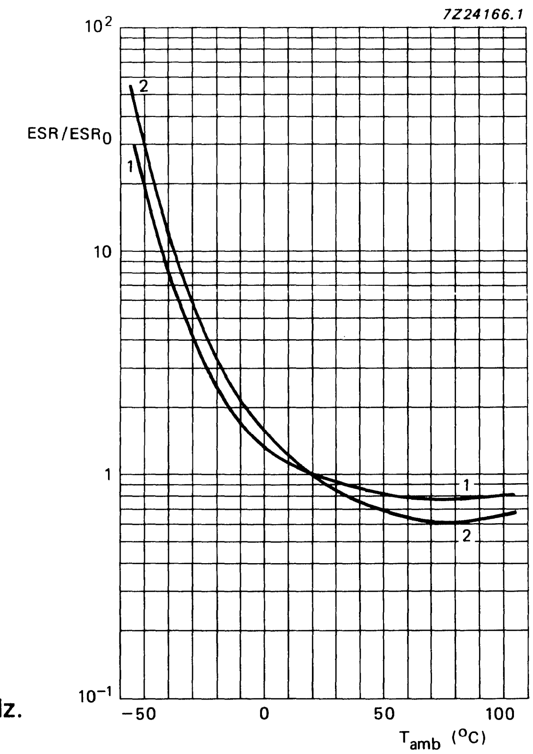


Curve 1: 50 V (≤2.2 µF)
Curve 2: 50 V (>2.2 µF)
Curve 3: 50 V (≥15 µF)
Curve 4: 35/40 V and 63/100 V
Curve 5: 25 V
Curve 6: 16 V
Curve 7: 6.3/10 V.

C_o = capacitance at 20 °C, 100 Hz.

Fig.8 Multiplier of capacitance (C/C_o) as a function of frequency.

Equivalent series resistance (ESR)

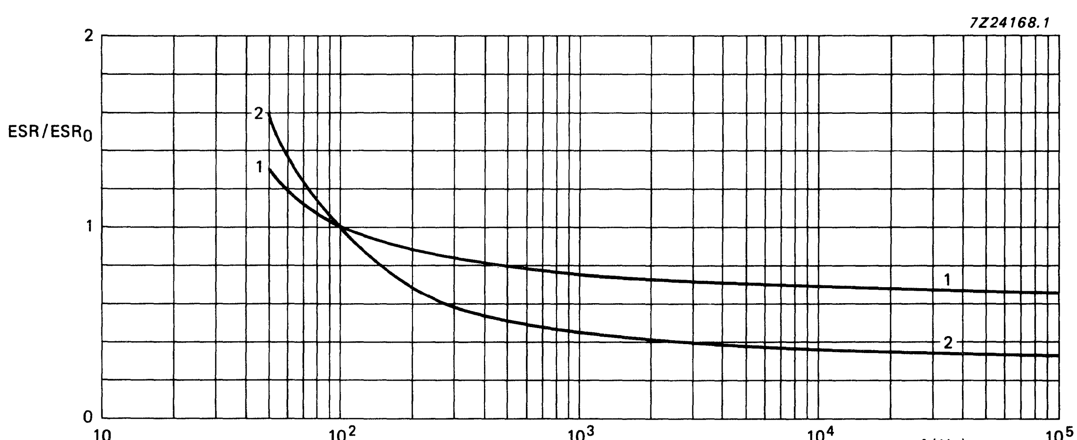


Curve 1 : 50 V (≥10 µF)

Curve 2 : 6.3 V and 63/100 V.

ESR$_o$ = typical ESR at 20 °C, 100 Hz.

Fig.9 Multiplier of ESR (ESR/ESR$_o$) as a function of ambient temperature.



Curve 1 : 6.3 V

Curve 2 : 50 V (≥10 µF) and 63/100 V.

ESR$_o$ = typical ESR at 20 °C, 100 Hz.

Fig.10 Multiplier of ESR (ESR/ESR$_o$) as a function of frequency.

Equivalent series inductance (ESL)

case size 5 x 11	typ. 13 nH
case size 8.2 x 11	typ. 16 nH

Impedance (Z)

Curve 1 : 0.47 μF
Curve 2 : 0.68 μF
Curve 3 : 1.0 μF
Curve 4 : 1.5 μF
Curve 5 : 2.2 μF
Curve 6 : 3.3 μF
Curve 7 : 4.7 μF
Curve 8 : 6.8 μF
Curve 9 : 10 μF
Curve 10 : 15 μF
Curve 11 : 22 μF
Curve 12 : 33 μF
Curve 13 : 47 μF
Curve 14 : 68 μF
Curve 15 : 100 μF
Curve 16 : 150 μF.

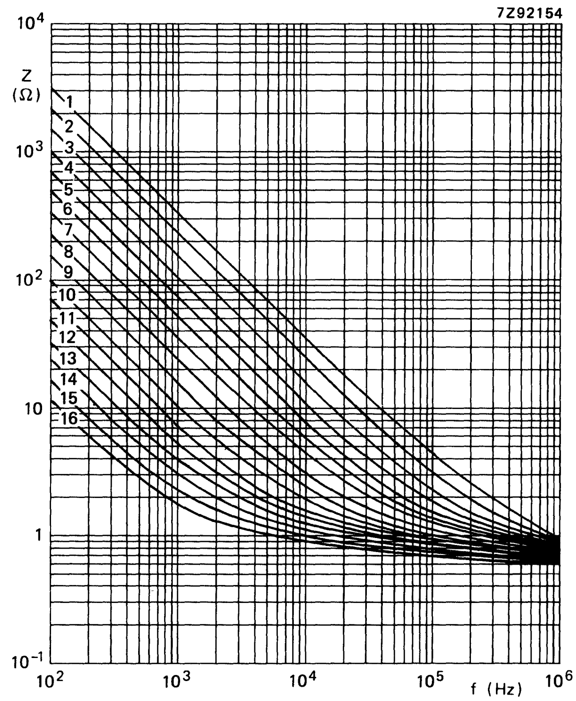


Fig.11 Typical impedance as a function of frequency at T_{amb} = 20 °C; case size 5 x 11.

Curve 1 : 2.2 µF
Curve 2 : 4.7 µF
Curve 3 : 10 µF/100 V
Curve 4 : 10 µF/50 V
Curve 5 : 22 µF/50 V
Curve 6 : 33 µF
Curve 7 : 47 µF
Curve 8 : 68 µF
Curve 9 : 100 µF
Curve 10 : 150 µF
Curve 11 : 220 µF
Curve 12 : 330 µF
Curve 13 : 470 µF.

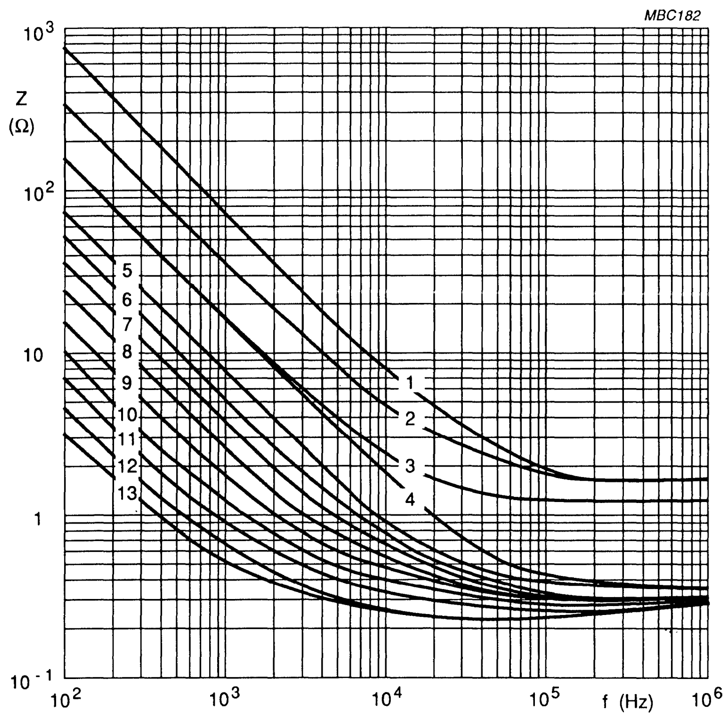
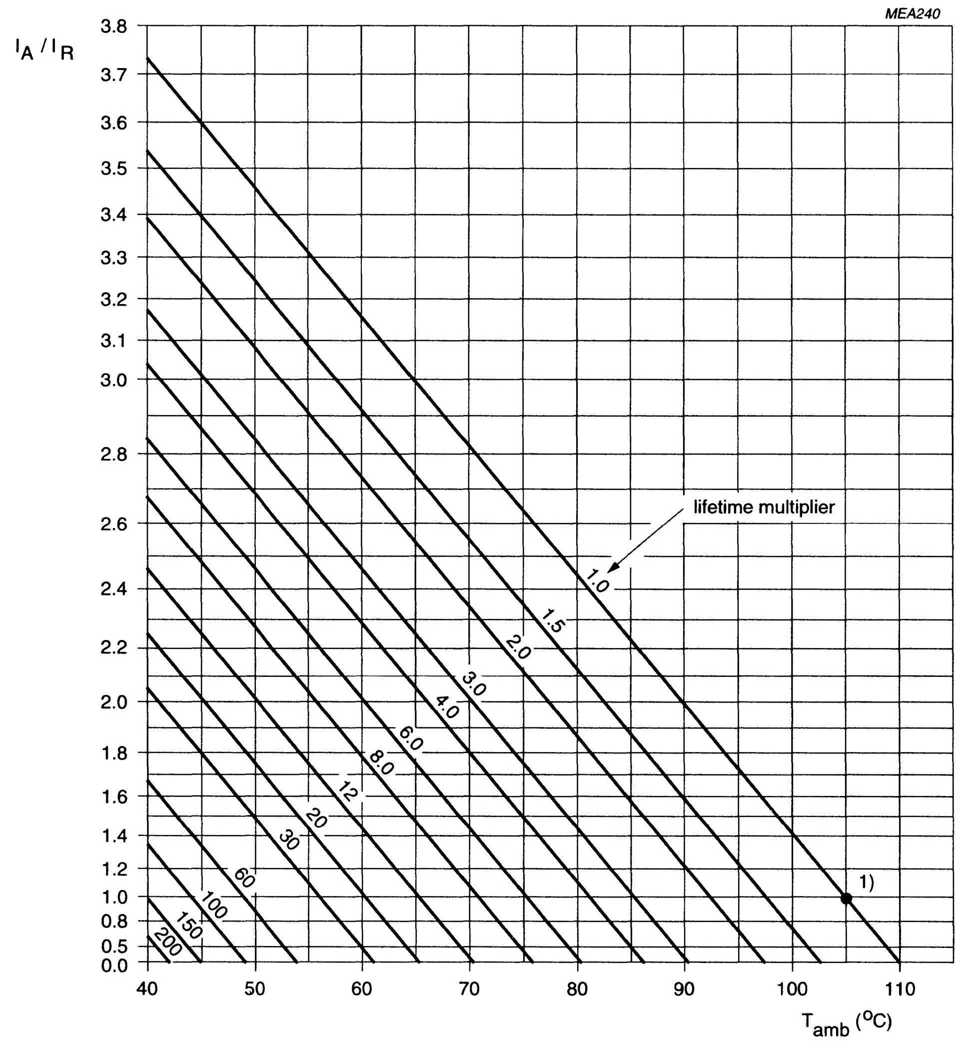


Fig.12 Typical impedance as a function of frequency at T_{amb} = 20 °C; case size 8.2 x 11.

RIPPLE CURRENT and USEFUL LIFE



I_A = actual ripple current at 100 Hz.

I_R = rated ripple current at 100 Hz, 105 °C.

1) Useful life at 105 °C and I_R applied: 2000 hours.

Fig.13 Multiplier of useful life as a function of ambient temperature and ripple current load (I_A/I_R).

Table 5 Multiplier of ripple current (I_R/I_{RO}) as a function of frequency; I_{RO} = ripple current at 100 Hz

FREQUENCY (Hz)	I_R MULTIPLIER		
	U_R = 6.3 to 10 V	U_R = 16 to 35 V	U_R = 40 to 100 V
50	0.9	0.85	0.8
100	1.0	1.0	1.0
300	1.12	1.2	1.25
1000	1.2	1.3	1.4
3000	1.25	1.35	1.5
≥10 000	1.3	1.4	1.6

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	Reference		
Endurance	IEC 384-4-1/ CECC 30301 sub clause 4.13	T_{amb} = 105 °C, U_R applied 1500 hours	U_R ≤6.3 V : ΔC/C +15/−30% U_R >6.3 V : ΔC/C ±15% tan δ ≤1.3 x spec. limit Z ≤2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 301 amendment 2640 sub clause 1.8.1	T_{amb} = 105 °C, U_R and I_R applied 2000 hours	U_R ≤6.3 V : ΔC/C +45/−50% U_R >6.3 V : ΔC/C ±45% tan δ ≤3 x spec. limit Z ≤3 x spec. limit I_{L5} ≤2 x spec. limit no short or open circuit total failure percentage: ≤1%
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30301 sub clause 4.17	T_{amb} = 105 °C, no voltage applied 1500 hours after test : U_R to be applied for 30 minutes, 24 to 48 hours before measurement	ΔC/C, tan δ, Z: for requirements see Endurance test above I_{L5} ≤2 x spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, non solid
- Radial leads, cylindrical aluminium case with safety vent insulated with a blue sleeve
- Charge and discharge proof
- Extended useful life, 5000/6000 h at 105 °C, high reliability
- High ripple current capability, low impedance

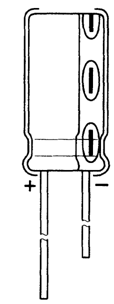


Fig.1 Component outline

APPLICATIONS

- Power supplies, EDP, telecommunication, industrial and audio-video
- Smoothing, filtering, buffering in SMPS
- Low PCB surface demand

QUICK REFERENCE DATA

Case size, øD_{nom} x L_{nom} in mm	10 x 12 to 18 x 40
Rated capacitance range, C_R	47 to 10000 µF
Tolerance on C_R	±20 %
Rated voltage range, U_R	10 to 63 V
Category temperature range	–40 to +105 °C
Endurance test at 105 °C	3000 hours
Useful life at 105 °C, case ø 10 and 12.5 mm case ø 16 and 18 mm	5000 hours 6000 hours
Useful life at 40 °C, 1.8 I_R applied case ø 10 and 12.5 mm case ø 16 and 18 mm	 240000 hours 280000 hours
Shelf life at 0 V, 105 °C	2000 hours
Basic specification	IEC 384-4, L.L. grade, CECC 30 300
Detail specification	similar to DIN 41 259
Climatic category IEC 68	40/105/56
Climatic category DIN 40 040	GMF

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Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (diameter x length in mm)

C_R	U_R (V)						
µF	10	16	25	35	40	50	63
47 *							10 x 12
68						10 x 12	10 x 16
100 *					10 x 12	10 x 16	10 x 20
150				10 x 12	10 x 16	10 x 20	12.5 x 20
220 *		10 x 12		10 x 16	10 x 20	12.5 x 20	12.5 x 25
330	10 x 12	10 x 16		10 x 20	12.5 x 20	12.5 x 25	16 x 25
470 *	10 x 16	10 x 20		12.5 x 20	12.5 x 25		16 x 25
680	10 x 20	12.5 x 20		12.5 x 25		16 x 25	16 x 31
1000 *	12.5 x 20	12.5 x 25		16 x 25		16 x 31	18 x 35
1500	12.5 x 25	16 x 25		16 x 31	16 x 35	18 x 35	18 x 40
2200 *		16 x 25	16 x 31	18 x 35	18 x 35	18 x 40	
3300		16 x 31	18 x 35		18 x 40		
4700 *	16 x 35	18 x 35	18 x 40				
6800	18 x 35	18 x 40					
10000 *	18 x 40						

* E3 values = preferred values

MECHANICAL DATA Dimensions (in mm)

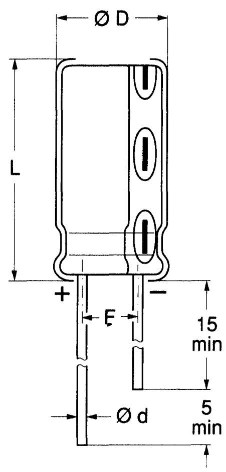


Fig. 2 **Form CA**, long leads;
see Table 2 for dimensions.

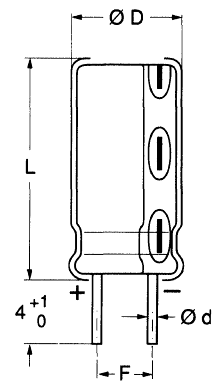
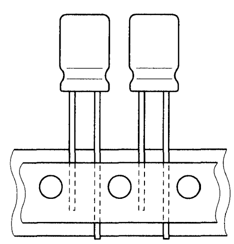
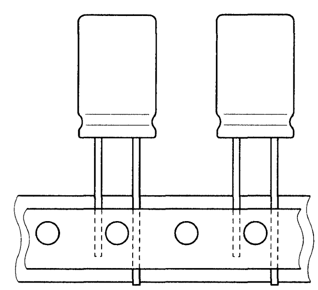


Fig. 3 **Form CB**, cut leads;
see Table 2 for dimensions.



øD = 10 mm and 12.5 mm



øD = 16 mm

Fig. 4 **Form TR+**, case sizes up to ø16 x 31 taped on reel, positive leading.
See Introduction for taping dimensions.

MARKING

The capacitors are marked with the following information:

- Rated capacitance value
- Tolerance on rated capacitance (M for ±20 %)
- Rated voltage
- Negative terminal identification
- Upper category temperature (105 °C)
- Group number (164)
- Code indicating factory of origin
- Name of manufacturer, PHILIPS
- Date code, in accordance with IEC 62

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Table 2 Dimensions (in mm)

CASE SIZE $øD_{nom}$ x L_{nom}	CASE CODE	RADIAL				MASS
		ød	$øD_{max}$	L_{max}	F ± 0,5	(g)
10 x 12	14	0.6	10.5	13.5	5.0	1.6
10 x 16	15	0.6	10.5	17.5	5.0	1.9
10 x 20	16	0.6	10.5	21.5	5.0	2.2
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0
16 x 25	19	0.8	16.5	27.0	7.5	8.0
16 x 31	20	0.8	16.5	33.0	7.5	9.0
16 x 35	21	0.8	16.5	37.0	7.5	11.5
18 x 35	22	0.8	18.5	37.0	7.5	14.5
18 x 40	23	0.8	18.5	42.0	7.5	16.0

PACKING

Capacitors of Form CA and Form CB are supplied in boxes, those of Form TR+ taped on reel.
The numbers per box and per reel are given in Table 3.

Table 3 Packing quantities

CASE SIZE $øD_{nom}$ x L_{nom}	CASE CODE	NUMBER OF CAPACITORS		
		FORM CA per Box	FORM CB per Box	FORM TR+ per Reel
10 x 12	14	1000	1000	500
10 x 16	15	500	500	500
10 x 20	16	500	500	500
12.5 x 20	17	200	200	200
12.5 x 25	18	200	200	200
16 x 25	19	200	200	150
16 x 31	20	200	200	150
16 x 35	21	150	150	
18 x 35	22	100	100	
18 x 40	23	100	100	

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Table 4 apply at an ambient temperature of 20 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75 %.

C_R	=	rated capacitance at 100 Hz, tolerance ±20 %
I_R	=	rated RMS ripple current at 100 Hz, 105 °C
I_{L1}	=	max. leakage current after 1 minute at U_R
I_{L5}	=	max. leakage current after 5 minutes at U_R
tan δ	=	max. dissipation factor at 100 Hz
ESR	=	equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)
Z	=	max. impedance at 10 kHz or 100 kHz

Table 4 Electrical data

U_R	C_R	CASE SIZE $øD_{nom}$ x L_{nom}	I_R	I_{L1}	I_{L5}	tan δ	ESR	Z	
								at 10 kHz	at 100 kHz
(V)	(μF)	(mm)	(mA)	(μA)	(μA)		(Ω)	(Ω)	(Ω)
10	330	10 x 12	270	69	10	0.15	0.65		0.39
	470	10 x 16	340	97	12	0.15	0.46		0.28
	680	10 x 20	440	140	17	0.15	0.32		0.19
	1000	12.5 x 20	590	200	23	0.15	0.21		0.13
	1500	12.5 x 25	740	300	33	0.17	0.16	0.12	
	4700	16 x 35	1400	940	97	0.23	0.07	0.04	
	6800	18 x 35	1600	1400	140	0.27	0.06	0.03	
	10000	18 x 40	1800	2000	200	0.35	0.05	0.03	
16	220	10 x 12	250	73	10	0.13	0.85		0.45
	330	10 x 16	320	110	14	0.13	0.56		0.30
	470	10 x 20	420	150	18	0.13	0.40		0.21
	680	12.5 x 20	550	220	25	0.13	0.27		0.15
	1000	12.5 x 25	720	320	35	0.13	0.19		0.10
	1500	16 x 25	920	480	51	0.15	0.14	0.09	
	2200	16 x 25	1000	710	73	0.17	0.11	0.06	
	3300	16 x 31	1300	1100	110	0.19	0.08	0.04	
	4700	18 x 35	1600	1500	150	0.21	0.06	0.03	
	6800	18 x 40	1800	2200	220	0.25	0.05	0.03	
25	2200	16 x 31	1200	1100	110	0.15	0.09	0.05	
	3300	18 x 35	1500	1700	170	0.17	0.07	0.03	
	4700	18 x 40	1800	2400	240	0.19	0.06	0.03	

ORDERING EXAMPLE

Electrolytic capacitors 2222 164 . . . . .

1000 µF/16 V, ±20 %

12.5 x 25, taped on reel, Form TR+

Catalogue number 2222 164 25102

Ordering information

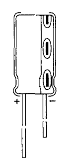
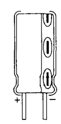
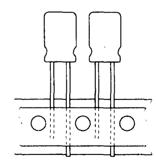
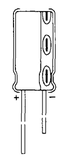
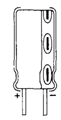
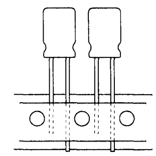
U_R	C_R	CASE SIZE $øD_{nom} \times L_{nom}$	CATALOGUE NUMBER 2222		
					
(V)	(µF)	(mm)	Form CA	Form CB	Form TR+
10	330	10 x 12	164 54331	164 64331	164 24331
	470	10 x 16	54471	64471	24471
	680	10 x 20	54681	64681	24681
	1000	12.5 x 20	54102	64102	24102
	1500	12.5 x 25	54152	64152	24152
	4700	16 x 35	54472	64472	
	6800	18 x 35	54682	64682	
	10000	18 x 40	54103	64103	
16	220	10 x 12	164 55221	164 65221	164 25221
	330	10 x 16	55331	65331	25331
	470	10 x 20	55471	65471	25471
	680	12.5 x 20	55681	65681	25681
	1000	12.5 x 25	55102	65102	25102
	1500	16 x 25	55152	65152	25152
	2200	16 x 25	55222	65222	25222
	3300	16 x 31	55332	65332	25332
	4700	18 x 35	55472	65472	
	6800	18 x 40	55682	65682	
25	2200	16 x 31	164 56222	164 66222	164 26222
	3300	18 x 35	56332	66332	
	4700	18 x 40	56472	66472	

Table 4 Electrical data (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom} \times L_{nom}$ (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
35	150	10 x 12	250	110	14	0.10	0.90		0.40
	220	10 x 16	320	160	18	0.10	0.62		0.27
	330	10 x 20	420	230	26	0.10	0.41		0.18
	470	12.5 x 20	550	330	36	0.10	0.29		0.13
	680	12.5 x 25	720	480	51	0.10	0.20		0.09
	1000	16 x 25	940	700	73	0.10	0.14		0.06
	1500	16 x 31	1200	1100	110	0.11	0.10	0.06	
	2200	18 x 35	1500	1500	160	0.12	0.07	0.04	
40	100	10 x 12	220	83	11	0.09	1.20		0.55
	150	10 x 16	280	120	15	0.09	0.81		0.37
	220	10 x 20	360	180	21	0.09	0.55		0.25
	330	12.5 x 20	480	270	29	0.09	0.37		0.17
	470	12.5 x 25	630	380	41	0.09	0.26		0.12
	1500	16 x 35	1300	1200	120	0.10	0.09	0.05	
	2200	18 x 35	1600	1800	180	0.11	0.07	0.04	
	3300	18 x 40	1900	2600	270	0.12	0.05	0.03	
50	68	10 x 12	210	71	10	0.07	1.30		0.74
	100	10 x 16	260	100	13	0.07	0.89		0.50
	150	10 x 20	350	150	18	0.07	0.59		0.33
	220	12.5 x 20	460	220	25	0.07	0.41		0.23
	330	12.5 x 25	620	330	36	0.07	0.27		0.15
	680	16 x 25	980	680	71	0.07	0.13		0.07
	1000	16 x 31	1300	1000	100	0.07	0.09		0.05
	1500	18 x 35	1600	1500	150	0.08	0.07	0.04	
	2200	18 x 40	1900	2200	220	0.09	0.05	0.03	
63	47	10 x 12	200	62	9	0.06	1.60		0.85
	68	10 x 16	250	89	12	0.06	1.10		0.59
	100	10 x 20	320	130	16	0.06	0.76		0.40
	150	12.5 x 20	430	190	22	0.06	0.51		0.27
	220	12.5 x 25	560	280	31	0.06	0.35		0.18
	330	16 x 25	760	420	45	0.06	0.23		0.12
	470	16 x 25	910	600	62	0.06	0.16		0.09
	680	16 x 31	1200	860	89	0.06	0.11		0.06
	1000	18 x 35	1500	1300	130	0.06	0.08		0.04
	1500	18 x 40	1800	1900	190	0.07	0.06	0.04	

Ordering information (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom}$ x L_{nom} (mm)	CATALOGUE NUMBER 2222 ... .  Form CA	 Form CB	 Form TR+
35	150	10 x 12	164 50151	164 60151	164 20151
	220	10 x 16	50221	60221	20221
	330	10 x 20	50331	60331	20331
	470	12.5 x 20	50471	60471	20471
	680	12.5 x 25	50681	60681	20681
	1000	16 x 25	50102	60102	20102
	1500	16 x 31	50152	60152	20152
	2200	18 x 35	50222	60222	
40	100	10 x 12	164 57101	164 67101	164 27101
	150	10 x 16	57151	67151	27151
	220	10 x 20	57221	67221	27221
	330	12.5 x 20	57331	67331	27331
	470	12.5 x 25	57471	67471	27471
	1500	16 x 35	57152	67152	
	2200	18 x 35	57222	67222	
	3300	18 x 40	57332	67332	
50	68	10 x 12	164 51689	164 61689	164 21689
	100	10 x 16	51101	61101	21101
	150	10 x 20	51151	61151	21151
	220	12.5 x 20	51221	61221	21221
	330	12.5 x 25	51331	61331	21331
	680	16 x 25	51681	61681	21681
	1000	16 x 31	51102	61102	21102
	1500	18 x 35	51152	61152	
	2200	18 x 40	51222	61222	
63	47	10 x 12	164 58479	164 68479	164 28479
	68	10 x 16	58689	68689	28689
	100	10 x 20	58101	68101	28101
	150	12.5 x 20	58151	68151	28151
	220	12.5 x 25	58221	68221	28221
	330	16 x 25	58331	68331	28331
	470	16 x 25	58471	68471	28471
	680	16 x 31	58681	68681	28681
	1000	18 x 35	58102	68102	
	1500	18 x 40	58152	68152	

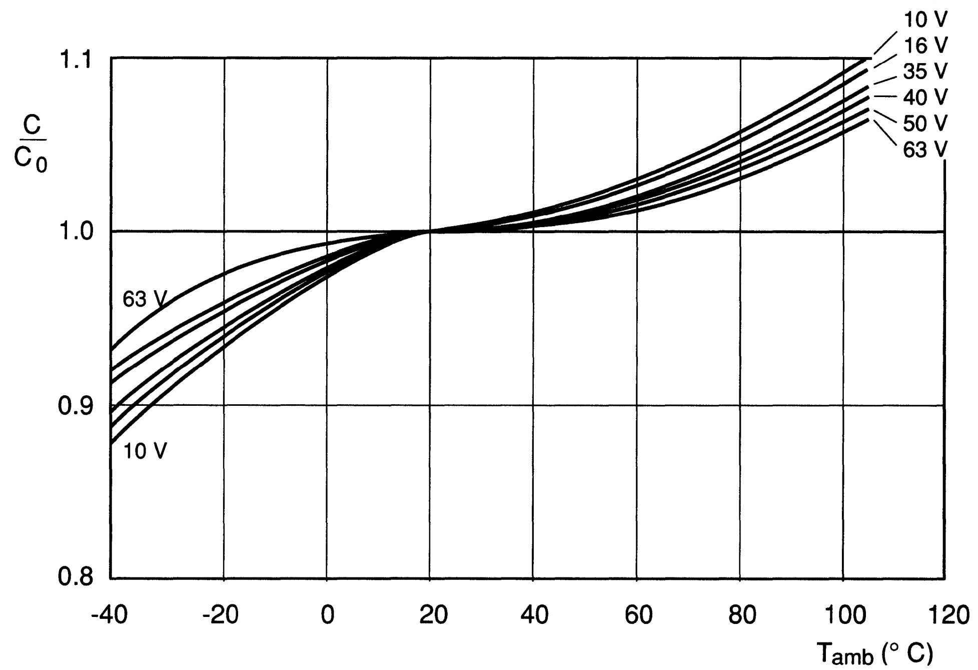


Fig. 5 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature; C_0 = Capacitance at 20 °C, 100 Hz.

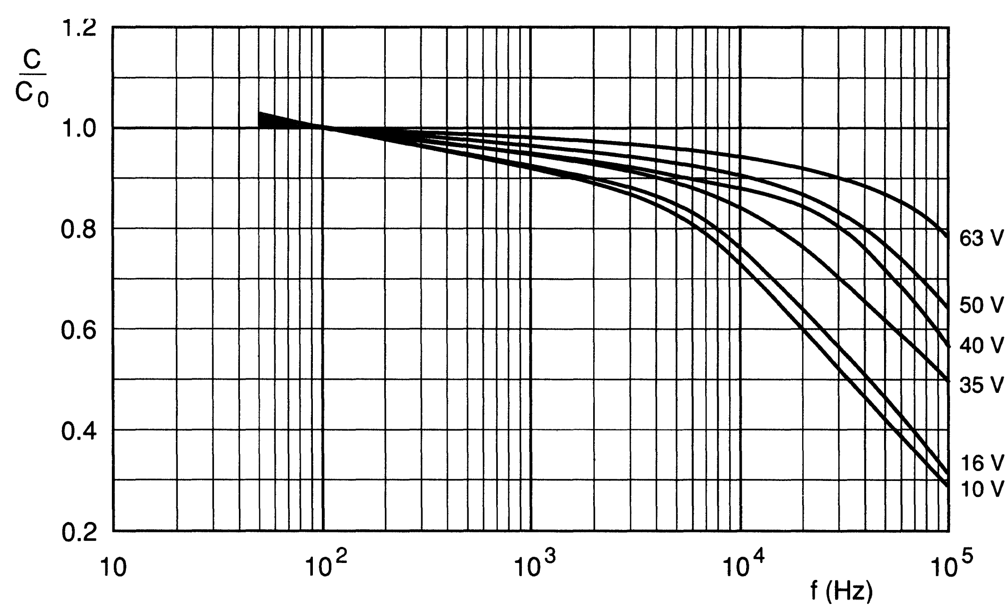


Fig. 6 Typical multiplier of capacitance (C/C_0) as a function of frequency; C_0 = Capacitance at 20 °C, 100 Hz.

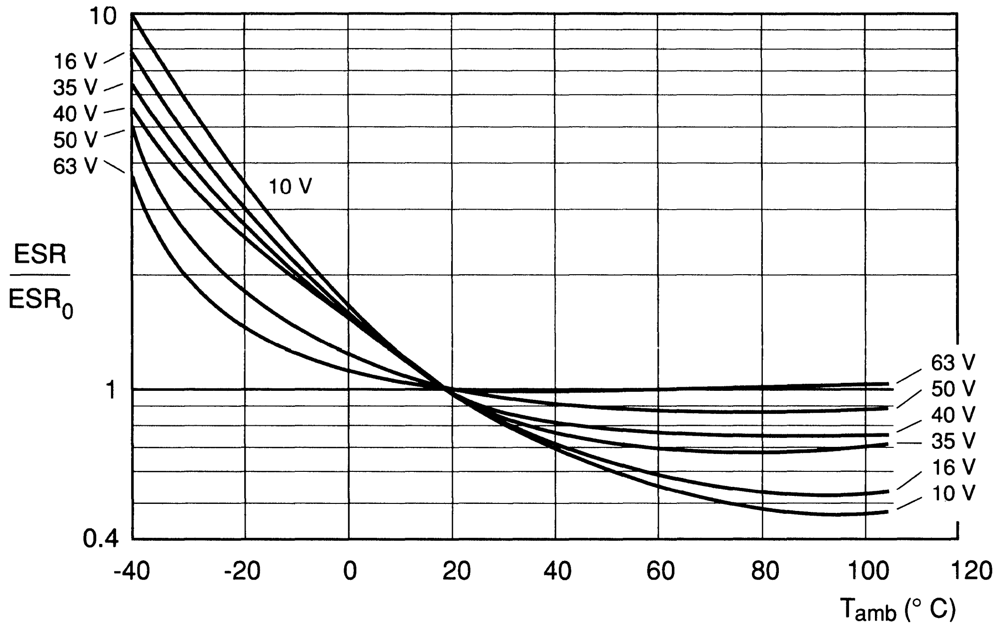


Fig. 7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature; ESR_0 = typical ESR at 20 °C, 100 Hz.

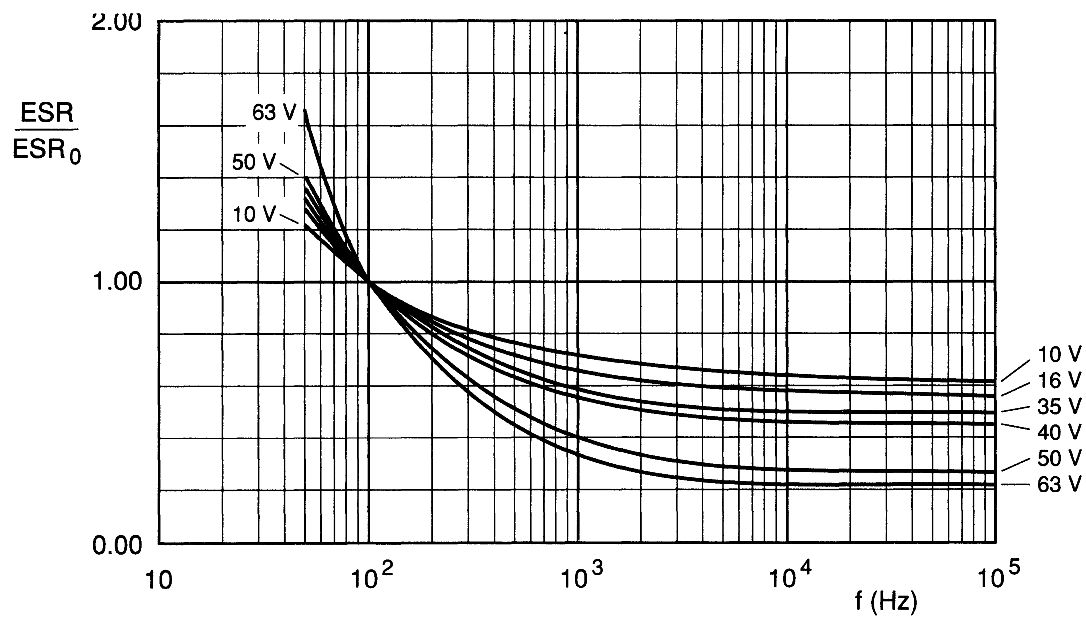


Fig. 8 Multiplier of ESR (ESR/ESR_0) as a function of frequency; ESR_0 = typical ESR at 20 °C, 100 Hz.

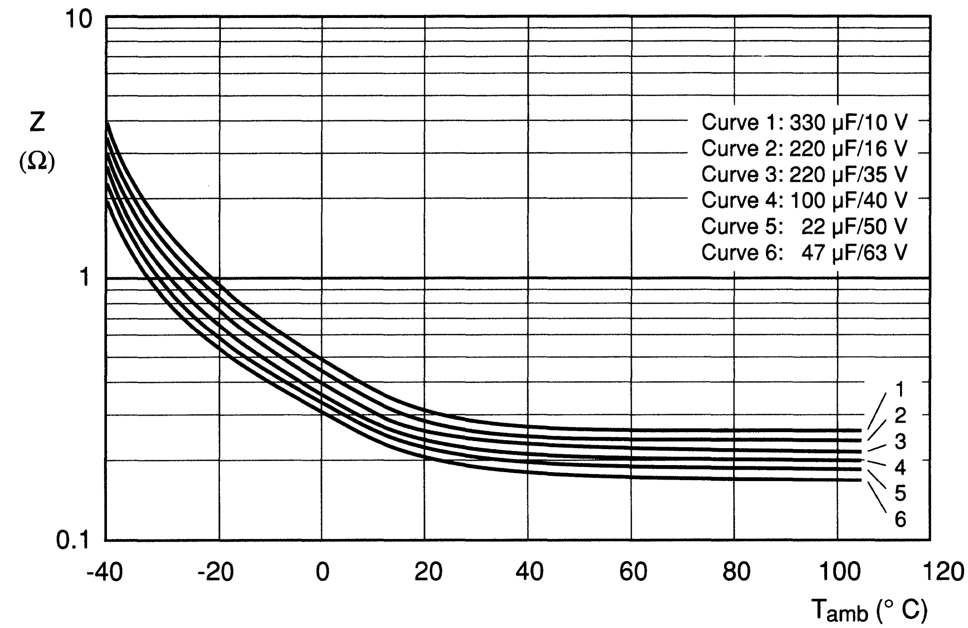


Fig. 9 Typical impedance at 100 kHz as a function of ambient temperature.

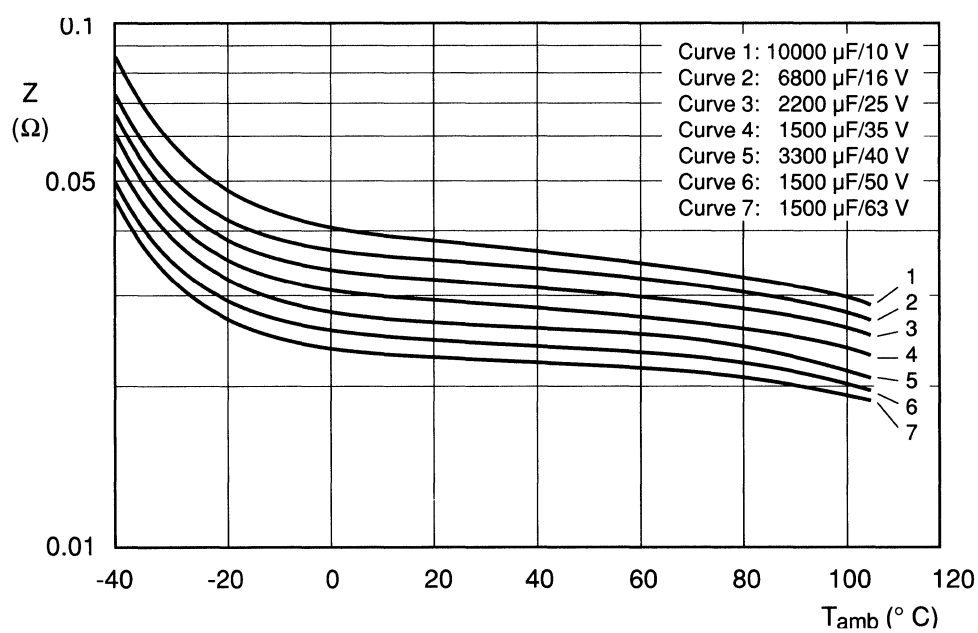


Fig. 10 Typical impedance at 10 kHz as a function of ambient temperature.

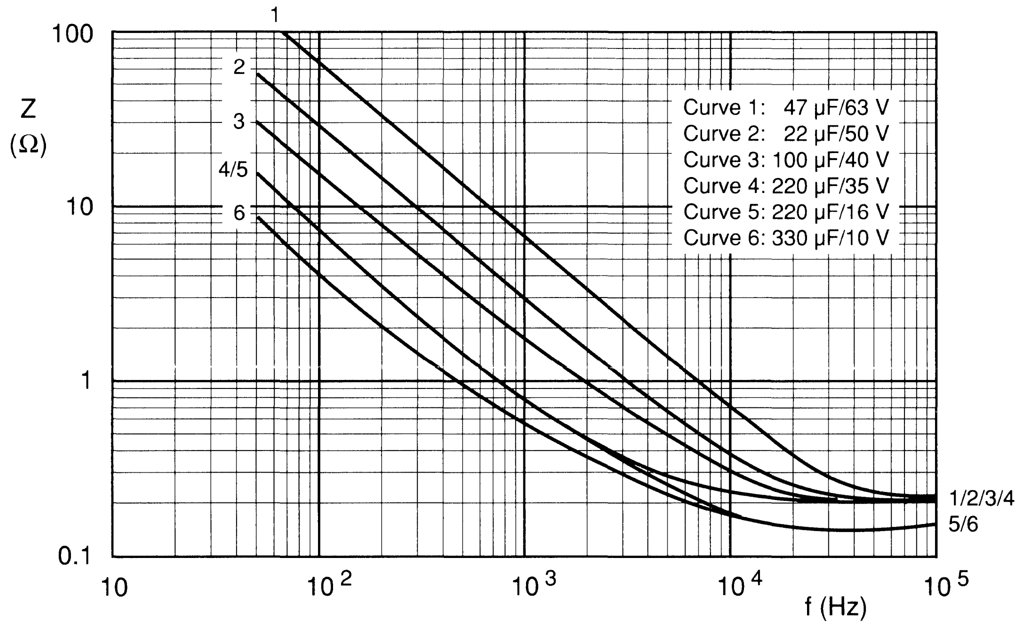


Fig. 11 Typical impedance as a function of frequency at T_{amb} = 20 °C.

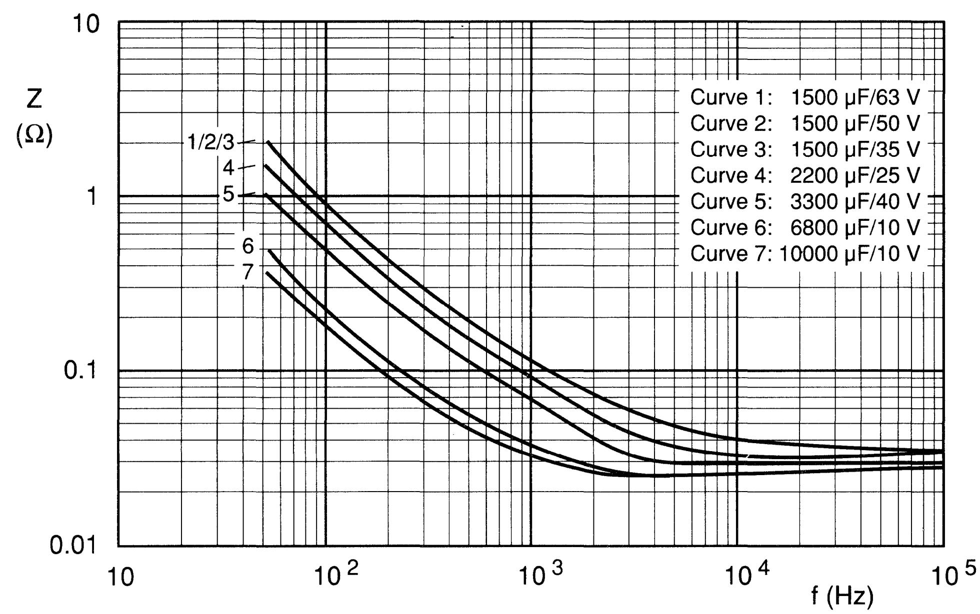


Fig. 12 Typical impedance as a function of frequency at T_{amb} = 20 °C.

USEFUL LIFE

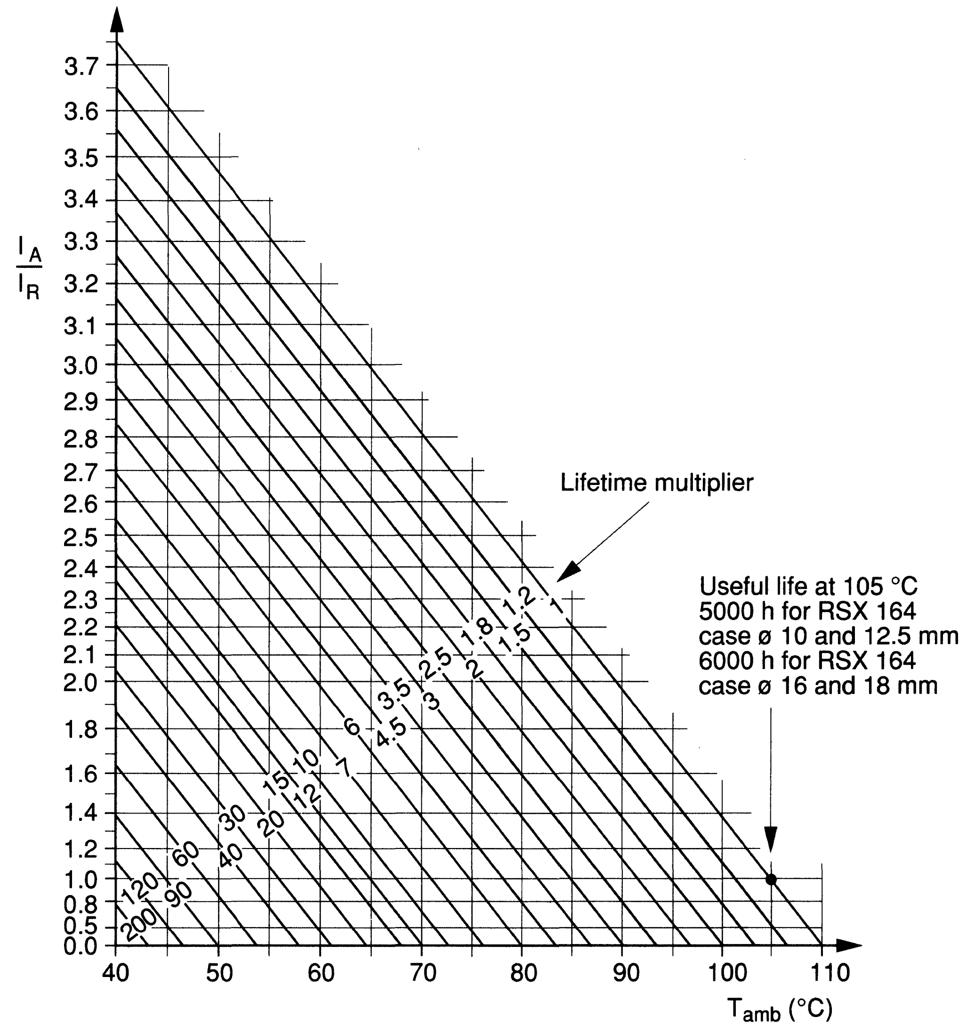


Fig. 13 Life expectancy (useful life) as a function of ripple current load (I_A/I_R) and ambient temperature.
I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz, 105 °C

Table 5 Multiplier of ripple current I_R as a function of frequency

FREQUENCY	I_R-MULTIPLIER		
	U_R = 10 to 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50 Hz	0.85	0.80	0.75
100 Hz	1.00	1.00	1.00
300 Hz	1.20	1.25	1.30
1000 Hz	1.30	1.40	1.50
3000 Hz	1.35	1.50	1.65
≥ 10000 Hz	1.40	1.60	1.80

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Voltage

Surge voltage for short periods	$U_s \leq 1.15\ U_R$
Reverse voltage	$U_{rev} \leq 1$ V

Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.02\ C_R\ U_R + 3\ \mu A$
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R\ U_R + 3\ \mu A$

Equivalent series inductance (ESL)

Case diameter = 10 mm	typ. 16 nH
Case diameter ≥ 12,5 mm	typ. 18 nH

SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE	SPECIFIC REQUIREMENTS
Name of test	Reference	(quick reference)	
Endurance	IEC 384-4-1/ CECC 30 301 group C 3, 4.13	T_{amb} = 105 °C, U_R applied 3000 hours	$\Delta C/C \leq \pm 15$ % tan $\delta \leq 1.3$ x spec. limit $Z \leq 2$ x spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30 301 amendment 2640, sub clause 1.8.1	T_{amb} = 105 °C, U_R and I_R applied 5000 hours case ø 10 and 12.5 mm 6000 hours case ø 16 and 18 mm	$\Delta C/C \leq \pm 45$ % tan $\delta \leq 3$ x spec. limit $Z \leq 3$ x spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 105 °C, no voltage applied 2000 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$\Delta C/C$, tan δ, Z: for requirements see Endurance test above $I_{L5} \leq 2$ x spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, non solid
- Radial leads, cylindrical aluminium case with safety vent insulated with a blue sleeve
- Charge and discharge proof
- Very long useful life, high stability, high reliability
- Extended temperature range 125 °C
- High ripple current capability

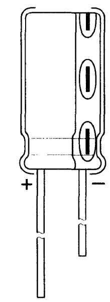

Fig.1 Component outline

APPLICATIONS

- EDB, telecommunication, industrial, automotive and military
- Smoothing, filtering, buffering in SMPS
- High ambient temperature environments
- Low PCB surface demand

QUICK REFERENCE DATA

Case size, $øD_{nom}$ x L_{nom} in mm	10 x 12 to 18 x 40
Rated capacitance range, C_R	33 to 4700 μF
Tolerance on C_R	±20 %
Rated voltage range, U_R	10 to 50 V
Category temperature range	–40 to +125 °C
Endurance test at 125 °C	1000 hours
Useful life at 125 °C	1500 hours
Useful life at 40 °C, 1.6 I_R applied	300000 hours
Shelf life at 0 V, 125 °C	500 hours
Basic specification	IEC 384-4, L.L. grade, CECC 30 300
Detail specification	similar to DIN 41 259
Climatic category IEC 68	40/125/56
Climatic category DIN 40 040	GKF

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Table 1 Selection chart for C_R, U_R and relevant nominal case sizes (diameter x length in mm)

C_R	U_R (V)					
μF	10	16	25	35	40	50
33						10 x 12
47 *					10 x 12	10 x 16
68				10 x 12	10 x 16	10 x 20
100 *			10 x 12	10 x 16	10 x 20	12.5 x 20
150		10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25
220 *	10 x 12	10 x 16	10 x 20		12.5 x 20	16 x 25
330	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31
470 *	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	16 x 35
680	12.5 x 20	12.5 x 25	16 x 25	16 x 31	16 x 35	18 x 35
1000 *		12.5 x 25	16 x 31		16 x 35	18 x 40
1500	16 x 25	16 x 31	16 x 35	18 x 35		
2200 *	16 x 31	16 x 35	18 x 40			
3300	16 x 35	18 x 40				
4700 *	18 x 40					

* E3 values = preferred values

MECHANICAL DATA Dimensions (in mm)

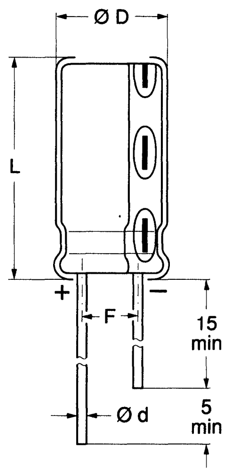


Fig. 2 **Form CA**, long leads;
see Table 2 for dimensions.

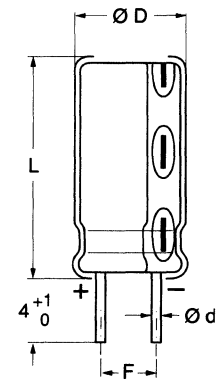


Fig. 3 **Form CB**, cut leads;
see Table 2 for dimensions.

øD = 10 mm and 12.5 mm

øD = 16 mm

Fig. 4 **Form TR+**, case sizes up to ø16 x 31 taped on reel, positive leading.
See Introduction for taping dimensions.

MARKING

The capacitors are marked with the following information:

- Rated capacitance value
- Tolerance on rated capacitance (M for ±20 %)
- Rated voltage
- Negative terminal identification
- Upper category temperature (125 °C)
- Group number (165)
- Code indicating factory of origin
- Name of manufacturer, PHILIPS
- Date code, in accordance with IEC 62

Table 2 Dimensions (in mm)

CASE SIZE $øD_{nom}$ x L_{nom}	CASE CODE	RADIAL				MASS
		ød	$øD_{max}$	L_{max}	F ± 0,5	(g)
10 x 12	14	0.6	10.5	13.5	5.0	1.6
10 x 16	15	0.6	10.5	17.5	5.0	1.9
10 x 20	16	0.6	10.5	21.5	5.0	2.2
12.5 x 20	17	0.6	13.0	21.5	5.0	4.0
12.5 x 25	18	0.6	13.0	26.5	5.0	5.0
16 x 25	19	0.8	16.5	27.0	7.5	8.0
16 x 31	20	0.8	16.5	33.0	7.5	9.0
16 x 35	21	0.8	16.5	37.0	7.5	11.5
18 x 35	22	0.8	18.5	37.0	7.5	14.5
18 x 40	23	0.8	18.5	42.0	7.5	16.0

PACKING

Capacitors of Form CA and Form CB are supplied in boxes, those of Form TR+ taped on reel.
The numbers per box and per reel are given in Table 3.

Table 3 Packing quantities

CASE SIZE $øD_{nom}$ x L_{nom}	CASE CODE	NUMBER OF CAPACITORS		
		FORM CA per Box	FORM CB per Box	FORM TR+ per Reel
10 x 12	14	1000	1000	500
10 x 16	15	500	500	500
10 x 20	16	500	500	500
12.5 x 20	17	200	200	200
12.5 x 25	18	200	200	200
16 x 25	19	200	200	150
16 x 31	20	200	200	150
16 x 35	21	150	150	
18 x 35	22	100	100	
18 x 40	23	100	100	

ELECTRICAL DATA and ORDERING INFORMATION

Unless otherwise specified, all electrical values in Table 4 apply at an ambient temperature of 20 °C, an atmospheric pressure of 86 to 106 kPa and a relative humidity of 45 to 75 %.

C_R = rated capacitance at 100 Hz, tolerance ±20 %

I_R = rated RMS ripple current at 100 Hz, 125 °C

I_{L1} = max. leakage current after 1 minute at U_R

I_{L5} = max. leakage current after 5 minutes at U_R

tan δ = max. dissipation factor at 100 Hz

ESR = equivalent series resistance at 100 Hz (calculated from tan δ_{max} and C_R)

Z = max. impedance at 10 kHz or 100 kHz

Table 4 Electrical data

U_R (V)	C_R (µF)	CASE SIZE øD$_{nom}$ x L$_{nom}$ (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
10	220	10 x 12	200	47	7	0.20	1.30		0.55
	330	10 x 16	260	69	10	0.20	0.87		0.36
	470	10 x 20	340	97	12	0.20	0.61		0.26
	680	12.5 x 20	440	140	17	0.20	0.42		0.18
	1500	16 x 25	750	300	33	0.22	0.21	0.10	
	2200	16 x 31	930	440	47	0.24	0.16	0.07	
	3300	16 x 35	1200	660	69	0.26	0.11	0.05	
	4700	18 x 40	1400	940	97	0.28	0.09	0.04	
16	150	10 x 12	190	51	8	0.16	1.50		0.63
	220	10 x 16	240	73	10	0.16	1.00		0.43
	330	10 x 20	320	110	14	0.16	0.69		0.29
	470	12.5 x 20	410	150	18	0.16	0.49		0.20
	680	12.5 x 25	540	220	25	0.16	0.34		0.14
	1000	12.5 x 25	650	320	35	0.16	0.23		0.10
	1500	16 x 31	910	480	51	0.18	0.17	0.07	
	2200	16 x 35	1100	710	73	0.20	0.13	0.05	
	3300	18 x 40	1400	1100	110	0.22	0.10	0.04	
25	100	10 x 12	170	53	8	0.14	2.00		0.70
	150	10 x 16	210	78	11	0.14	1.30		0.47
	220	10 x 20	280	110	14	0.14	0.91		0.32
	330	12.5 x 20	370	170	20	0.14	0.61		0.21
	470	12.5 x 25	480	240	27	0.14	0.43		0.15
	680	16 x 25	630	340	37	0.14	0.30		0.10
	1000	16 x 31	830	500	53	0.14	0.20		0.07
	1500	16 x 35	1000	750	78	0.16	0.15	0.06	
	2200	18 x 40	1200	1100	110	0.18	0.12	0.04	

ORDERING EXAMPLE

Electrolytic capacitors 2222 165 . . . . .
1500 µF/16 V, ±20 %
16 x 31, taped on reel, Form TR+
Catalogue number 2222 165 25152

Ordering information

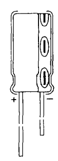
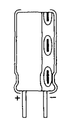
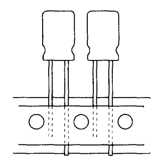
U_R	C_R	CASE SIZE	CATALOGUE NUMBER 2222		
		$øD_{nom}$ x L_{nom}			
(V)	(µF)	(mm)	Form CA	Form CB	Form TR+
10	220	10 x 12	165 54221	165 64221	165 24221
	330	10 x 16	54331	64331	24331
	470	10 x 20	54471	64471	24471
	680	12.5 x 20	54681	64681	24681
	1500	16 x 25	54152	64152	24152
	2200	16 x 31	54222	64222	24222
	3300	16 x 35	54332	64332	
	4700	18 x 40	54472	64472	
16	150	10 x 12	165 55151	165 65151	165 25151
	220	10 x 16	55221	65221	25221
	330	10 x 20	55331	65331	25331
	470	12.5 x 20	55471	65471	25471
	680	12.5 x 25	55681	65681	25681
	1000	12,5 x 25	55102	65102	25102
	1500	16 x 31	55152	65152	25152
	2200	16 x 35	55222	65222	
	3300	18 x 40	55332	65332	
25	100	10 x 12	165 56101	165 66101	165 26101
	150	10 x 16	56151	66151	26151
	220	10 x 20	56221	66221	26221
	330	12.5 x 20	56331	66331	26331
	470	12.5 x 25	56471	66471	26471
	680	16 x 25	56681	66681	26681
	1000	16 x 31	56102	66102	26102
	1500	16 x 35	56152	66152	
	2200	18 x 40	56222	66222	

Table 4 Electrical data (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom} \times L_{nom}$ (mm)	I_R (mA)	I_{L1} (µA)	I_{L5} (µA)	tan δ	ESR (Ω)	Z at 10 kHz (Ω)	Z at 100 kHz (Ω)
35	68	10 x 12	160	51	8	0.12	2.50		0.96
	100	10 x 16	200	73	10	0.12	1.70		0.65
	150	10 x 20	270	110	14	0.12	1.10		0.43
	330	12.5 x 25	460	230	26	0.12	0.52		0.20
	470	16 x 25	600	330	36	0.12	0.37		0.14
	680	16 x 31	790	480	51	0.12	0.25		0.10
	1500	18 x 35	1200	1100	110	0.13	0.12	0.05	
40	47	10 x 12	130	41	7	0.12	3.70		1.30
	68	10 x 16	160	57	8	0.12	2.50		0.88
	100	10 x 20	210	83	11	0.12	1.70		0.60
	150	12.5 x 20	290	120	15	0.12	1.10		0.40
	220	12.5 x 20	340	180	21	0.12	0.78		0.27
	330	16 x 25	510	270	29	0.12	0.52		0.18
	470	16 x 31	650	380	41	0.12	0.37		0.13
	680	16 x 35	830	550	57	0.12	0.25		0.09
	1000	16 x 35	1000	800	83	0.12	0.17		0.06
50	33	10 x 12	120	36	6	0.10	4.30		1.50
	47	10 x 16	150	50	8	0.10	3.00		1.10
	68	10 x 20	190	71	10	0.10	2.10		0.74
	100	12.5 x 20	260	100	13	0.10	1.40		0.50
	150	12.5 x 25	340	150	18	0.10	0.96		0.33
	220	16 x 25	450	220	25	0.10	0.65		0.23
	330	16 x 31	600	330	36	0.10	0.43		0.15
	470	16 x 35	760	470	50	0.10	0.30		0.11
	680	18 x 35	920	680	71	0.10	0.21		0.07
	1000	18 x 40	1200	1000	100	0.10	0.14		0.05

Voltage

Surge voltage for short periods	$U_s \leq 1.5\ U_R$
Reverse voltage	$U_{rev} \leq 1$ V

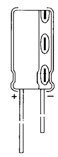
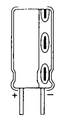
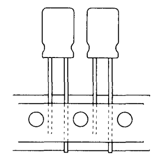
Leakage current

After 1 minute at U_R	$I_{L1} \leq 0.02\ C_R\ U_R + 3$ µA
After 5 minutes at U_R	$I_{L5} \leq 0.002\ C_R\ U_R + 3$ µA

Equivalent series inductance (ESL)

Case diameter = 10 mm	typ. 16 nH
Case diameter ≥ 12,5 mm	typ. 18 nH

Ordering information (continued)

U_R (V)	C_R (µF)	CASE SIZE $øD_{nom}$ x L_{nom} (mm)	CATALOGUE NUMBER 2222 ... .  Form CA	 Form CB	 Form TR+
35	68	10 x 12	165 50689	165 60689	165 20689
	100	10 x 16	50101	60101	20101
	150	10 x 20	50151	60151	20151
	330	12.5 x 25	50331	60331	20331
	470	16 x 25	50471	60471	20471
	680	16 x 31	50681	60681	20681
	1500	18 x 35	50152	60152	
40	47	10 x 12	165 57479	165 67479	165 27479
	68	10 x 16	57689	67689	27689
	100	10 x 20	57101	67101	27101
	150	12.5 x 20	57151	67151	27151
	220	12.5 x 20	57221	67221	27221
	330	16 x 25	57331	67331	27331
	470	16 x 31	57471	67471	27471
	680	16 x 35	57681	67681	
	1000	16 x 35	57102	67102	
50	33	10 x 12	165 51339	165 61339	165 21339
	47	10 x 16	51479	61479	21479
	68	10 x 20	51689	61689	21689
	100	12.5 x 20	51101	61101	21101
	150	12.5 x 25	51151	61151	21151
	220	16 x 25	51221	61221	21221
	330	16 x 31	51331	61331	21331
	470	16 x 35	51471	61471	
	680	18 x 35	51681	61681	
	1000	18 x 40	51102	61102	

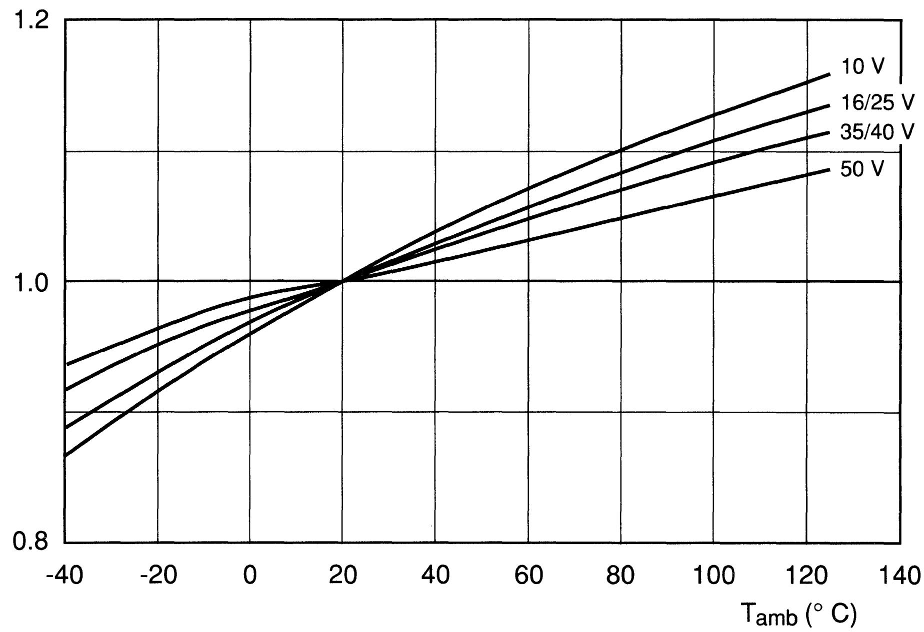


Fig. 5 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature; C_0 = Capacitance at 20 °C, 100 Hz.

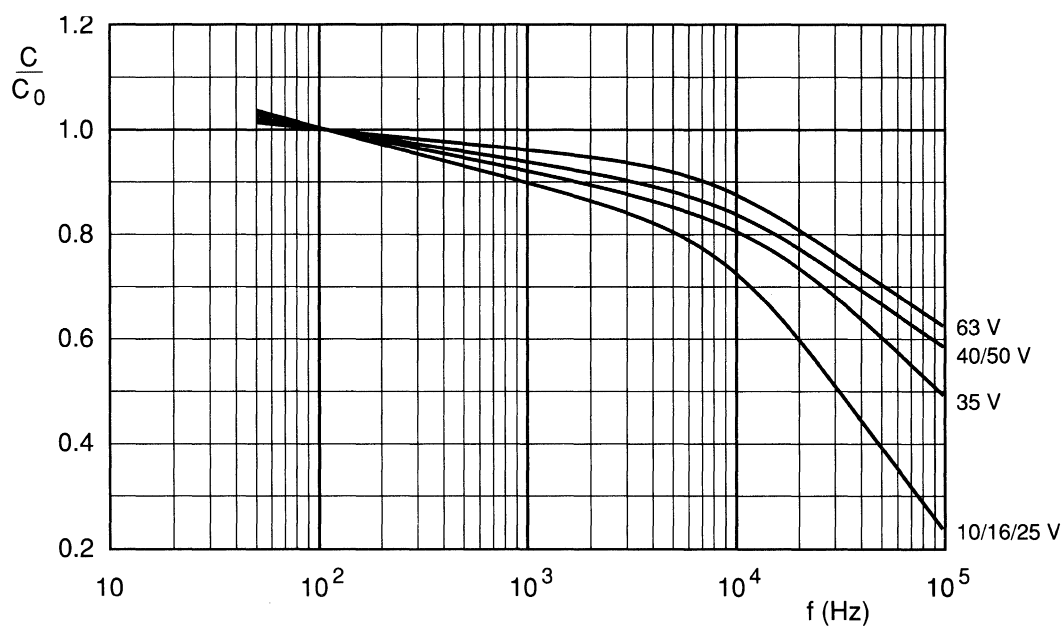


Fig. 6 Typical multiplier of capacitance (C/C_0) as a function of frequency; C_0 = Capacitance at 20 °C, 100 Hz.

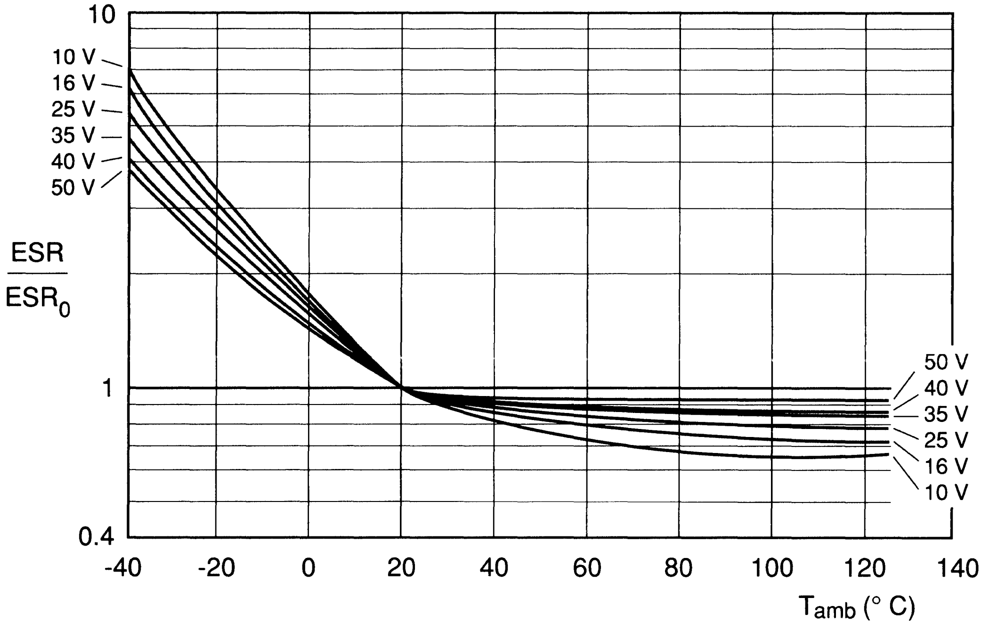


Fig. 7 Multiplier of ESR (ESR/ESR_0) as a function of ambient temperature;
ESR_0 = typical ESR at 20 °C, 100 Hz.

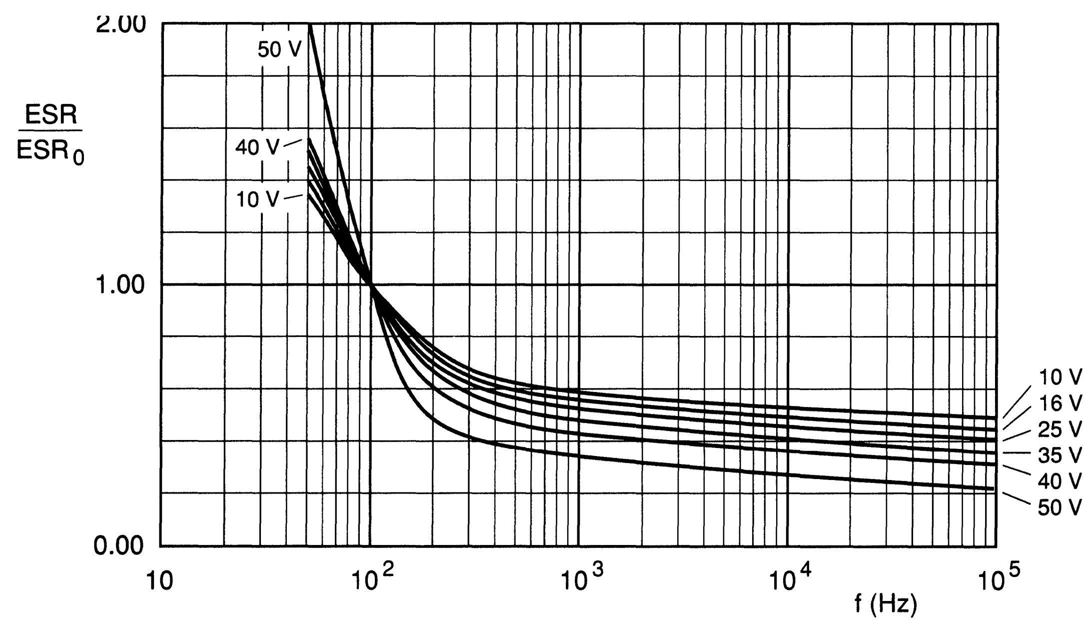


Fig. 8 Multiplier of ESR (ESR/ESR_0) as a function of frequency;
ESR_0 = typical ESR at 20 °C, 100 Hz.

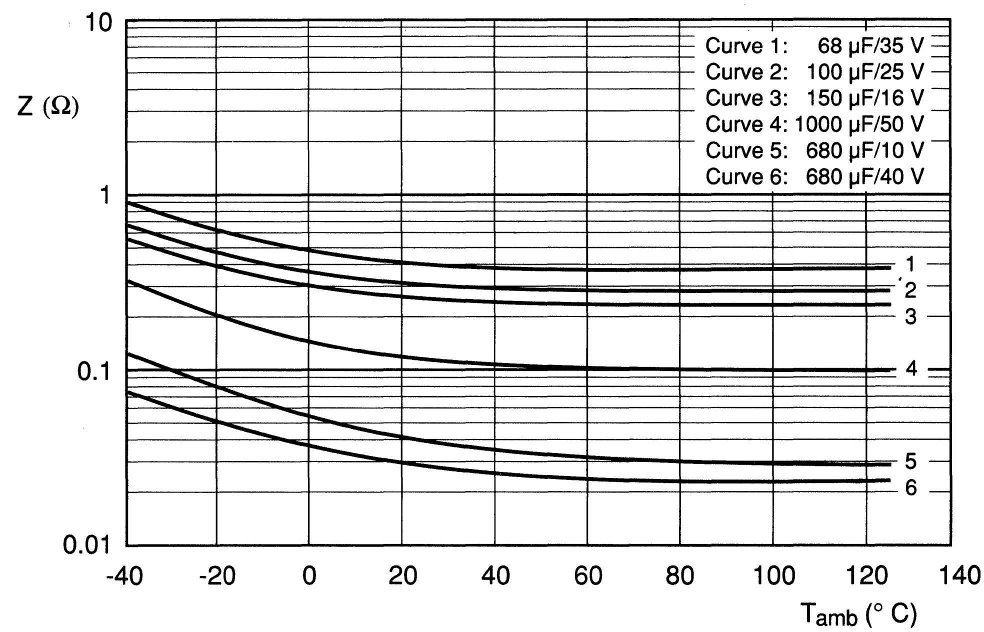


Fig. 9 Typical impedance at 100 kHz as a function of ambient temperature.

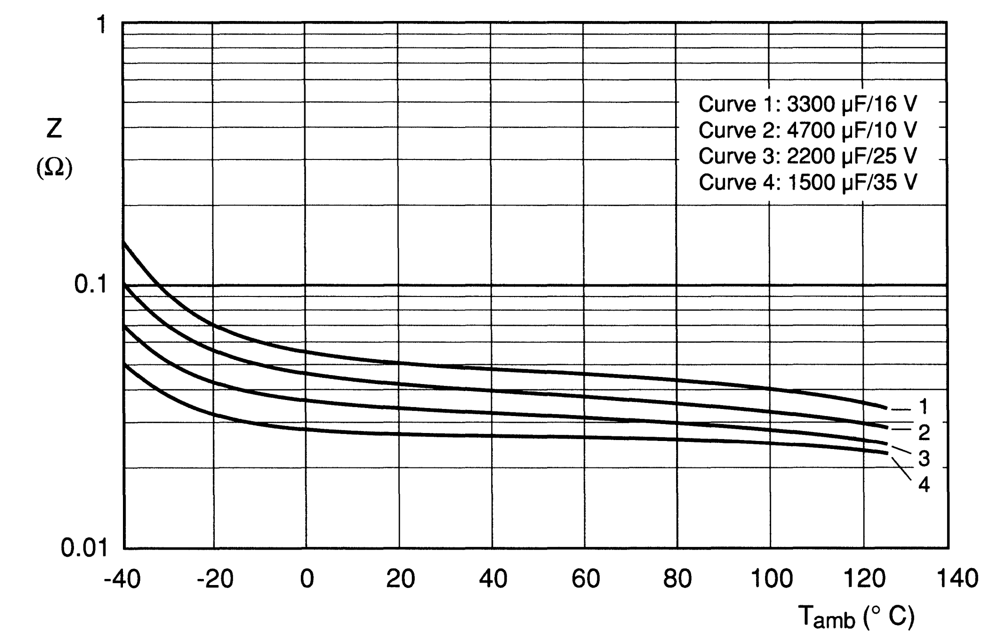


Fig. 10 Typical impedance at 10 kHz as a function of ambient temperature.

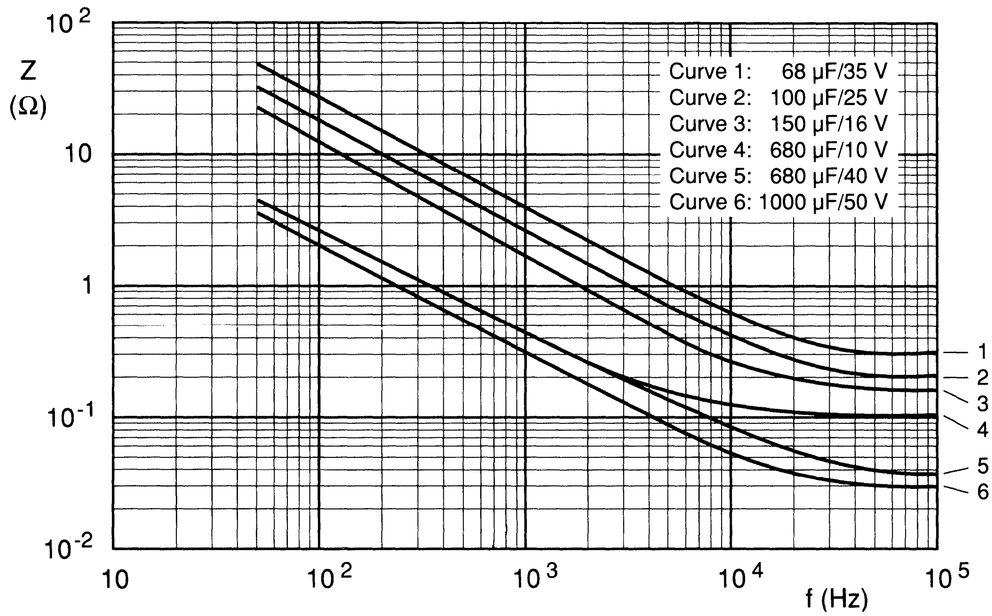


Fig. 11 Typical impedance as a function of frequency at T_{amb} = 20 °C.

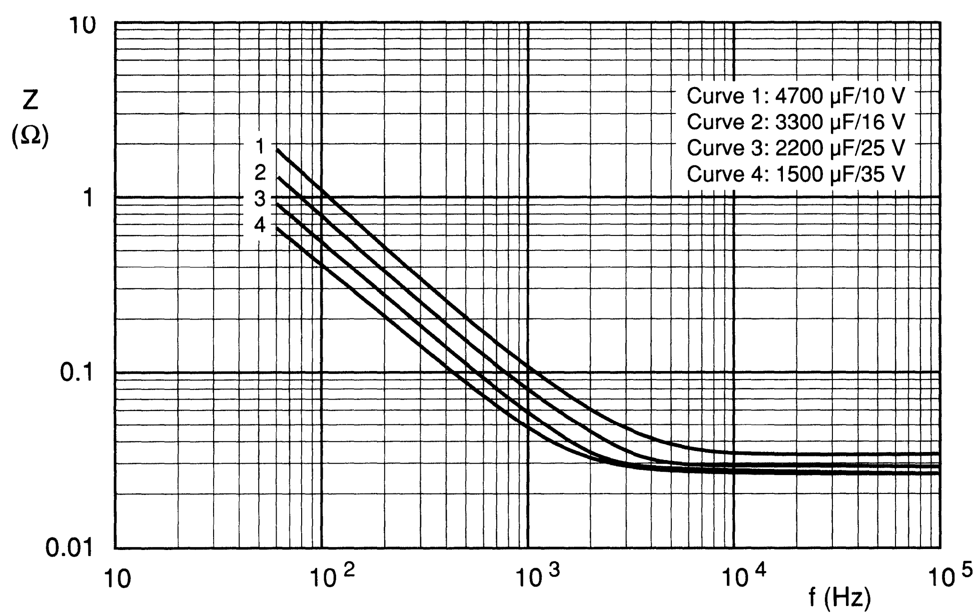


Fig. 12 Typical impedance as a function of frequency at T_{amb} = 20 °C.

USEFUL LIFE

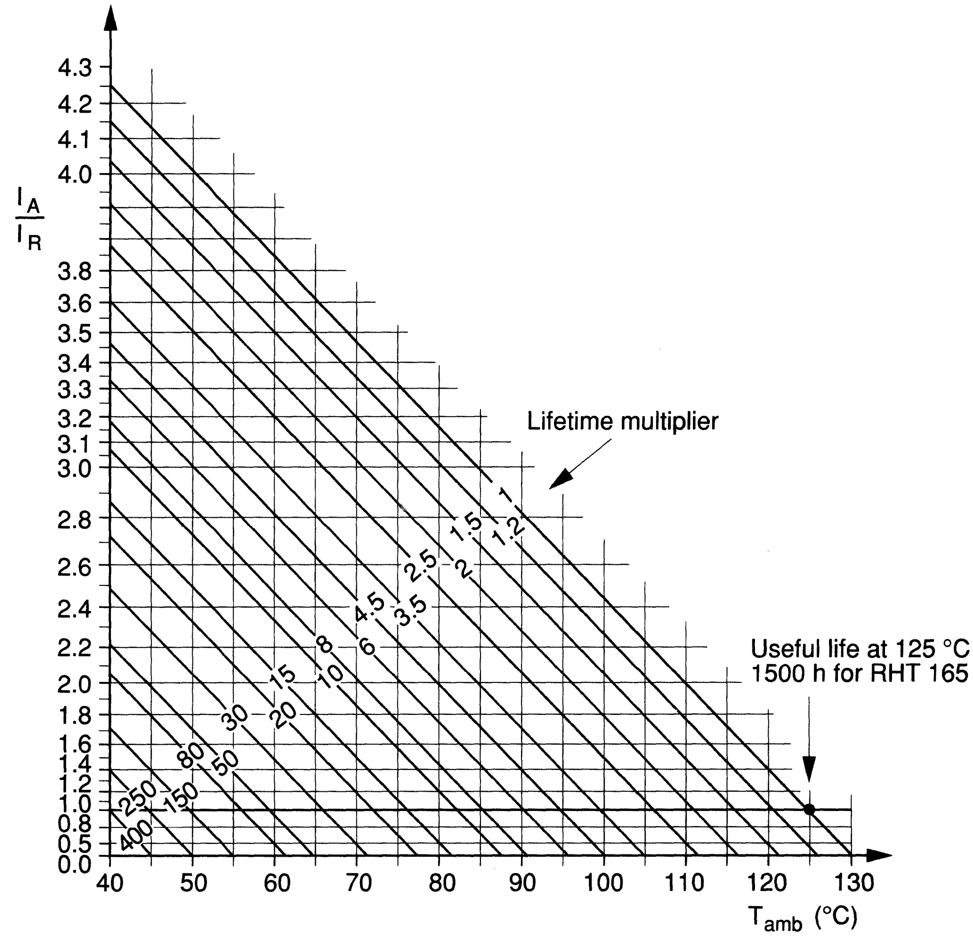


Fig. 13 Life expectancy (useful life) as a function of ripple current load (I_A/I_R) and ambient temperature.
I_A = actual ripple current at 100 Hz
I_R = rated ripple current at 100 Hz, 125 °C

Table 5 Multiplier of ripple current I_R as a function of frequency

FREQUENCY	I_R-MULTIPLIER		
	U_R = 10 to 25 V	U_R = 35 and 40 V	U_R = 50 and 63 V
50 Hz	0.85	0.80	0.75
100 Hz	1.00	1.00	1.00
300 Hz	1.20	1.25	1.30
1000 Hz	1.30	1.40	1.50
3000 Hz	1.35	1.50	1.65
≥ 10000 Hz	1.40	1.60	1.80

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SPECIFIC TESTS AND REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements",

Table 6

TEST		PROCEDURE	SPECIFIC REQUIREMENTS
Name of test	**Reference**	**(quick reference)**	
Endurance	IEC 384-4-1/ CECC 30 301, group C 3, 4.13	T_{amb} = 125 °C, U_R applied 1000 hours	$\Delta C/C \leq \pm 15$ % tan $\delta \leq 1.3$ x spec. limit $Z \leq 2$ x spec. limit $I_{L5} \leq$ spec. limit
Useful life	CECC 30 301, amendment 2640, sub clause 1.8.1	T_{amb} = 125 °C, U_R and I_R applied 1500 hours	$\Delta C/C \leq \pm 45$ % tan $\delta \leq 3$ x spec. limit $Z \leq 3$ x spec. limit $I_{L5} \leq$ spec. limit no short or open circuit total failure percentage: ≤ 1 %
Shelf life (storage at high temp.)	IEC 384-4-1/ CECC 30 301, group C 5a, 4.17	T_{amb} = 125 °C, no voltage applied 500 hours after test: U_R to be applied for 30 minutes, 24 to 48 hours before measurement	$\Delta C/C$, tan δ, Z: for requirements see Endurance test above $I_{L5} \leq 2$ x spec. limit

FEATURES

- Polarized aluminium electrolytic capacitors, solid electrolyte MnO_2
- Axial leads, aluminium case, ceramic seal, blue insulation sleeve
- SAL-A : standard version
- SAL-AG : epoxy filled shock-proof version up to 10 000 g
- Extremely long useful life 20 000 hours/125 °C
- Extended usable temperature range up to 200 °C
- Excellent low temperature impedance and ESR behaviour
- Charge and discharge proof, application with 0 Ω resistance allowed
- Reverse DC voltage up to 0.3 x U_R allowed
- AC voltage up to 0.8 x U_R allowed
- Advanced technology to achieve high reliability and high stability.

APPLICATIONS

- EDP, telecommunications, general industrial, automotive, military and space
- Smoothing, filtering, buffering, timing
- For power supplies, DC/DC converters.

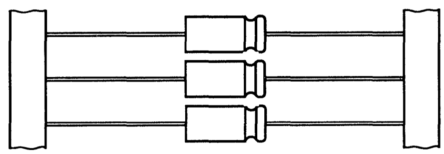


Fig.1 Component outline.

QUICK REFERENCE DATA

Case size (∅D_{max} x L_{max} in mm)	6.7 x 15.3 to 12.9 x 32.0
Rated capacitance range (E6 series), C_R	1.0 to 2200 µF
Tolerance on C_R	±20%, ±10% on request
Rated voltage range, U_R	4 to 40 V
Category temperature range	–55 to +125 °C
Usable temperature range	–80 to +200 °C
Endurance test at 155/125 °C	5 000 hours/8 000 hours
Useful life at U_R, 40 °C, I_R applied	450 000 hours
Shelf life at 0 V, 125 °C	500 hours
Basic specifications	IEC 384-4, CECC 30 300
Climatic category IEC 68 DIN 40040 NF C20-600	 55/125/56 FKD 434
Approvals	CECC 30 302-003 CNET LNZ 44-04 COS-C (PTT) Gam-t-1(MIL)

Table 1 Selection chart for C_R, U_R and relevant maximum case sizes (**∅D x L** in **mm)** for 123 series

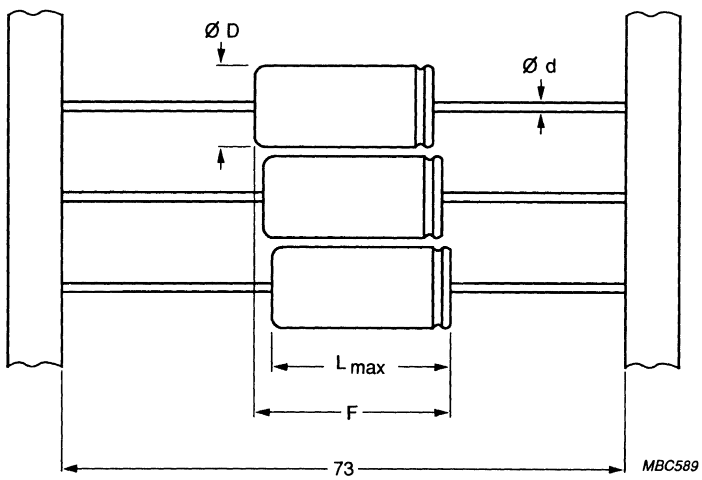
C_R (μF)	U_R (V)							
	4	**6.3**	**10**	**16**	**20**	**25**	**35**	**40 [1)]**
1.0							6.7 x 15.3	
1.5							6.7 x 15.3	
2.2							6.7 x 15.3	6.7 x 15.3
3.3							6.7 x 15.3	6.7 x 15.3
4.7							6.7 x 15.3	6.7 x 15.3
6.8							6.7 x 15.3	6.7 x 15.3
10				6.7 x 15.3	6.7 x 15.3	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4
15				6.7 x 15.3	6.7 x 15.3	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4
22				6.7 x 15.3		7.6 x 20.4	7.6 x 20.4	9.3 x 23.3
33			6.7 x 15.3	7.6 x 20.4		7.6 x 20.4	9.3 x 23.3	9.3 x 23.3
47		6.7 x 15.3	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4	7.6 x 20.4	9.3 x 23.3	10.3 x 32.0
68	6.7 x 15.3	6.7 x 15.3	7.6 x 20.4	7.6 x 20.4		9.3 x 23.3	10.3 x 32.0	10.3 x 32.0
100	6.7 x 15.3		7.6 x 20.4	9.3 x 23.3	9.3 x 23.3	9.3 x 23.3	12.9 x 32.0	12.9 x 32.0
150		7.6 x 20.4	9.3 x 23.3	9.3 x 23.3	10.3 x 32.0	10.3 x 32.0	12.9 x 32.0	
220	7.6 x 20.4		9.3 x 23.3	10.3 x 32.0	10.3 x 32.0	12.9 x 32.0		
330		9.3 x 23.3	10.3 x 32.0	10.3 x 32.0	12.9 x 32.0	12.9 x 32.0		
470	9.3 x 23.3		10.3 x 32.0	12.9 x 32.0	12.9 x 32.0			
680		10.3 x 32.0	12.9 x 32.0	12.9 x 32.0				
1000	10.3 x 32.0	12.9 x 32.0	12.9 x 32.0					
1500	12.9 x 32.0	12.9 x 32.0						
2200	12.9 x 32.0							

Note

[1)] Non CECC-types.

MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.
Tape dimensions are specified in chapter "PACKING".



BA: taped in box, (ammopack).

BR: taped on reel.

Fig.2 **Forms**: BA and BR.

Table 2 Dimensions in mm; mass in g

CASE		F_{min}	Ød	APPROX. MASS [1]	PACKING QUANTITIES	
SIZE $ØD_{max} \times L_{max}$	CODE				FORM BA	FORM BR
6.7 x 15.3	1	20.0	0.6	1.05	100	800
7.6 x 20.4	2A	22.5	0.6	1.55	100	800
9.3 x 23.3	4	25.0	0.6	2.6	100	500
10.3 x 32.0	5	35.0	0.8	4.2	100	500
12.3 x 32.0	6	35.0	0.8	7	100	400

Note

[1] Add 10% for SAL-AG epoxy-filled versions.

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MARKING

- Rated capacitance
- Tolerance code on rated capacitance (M = ±20%, K = ±10%, in accordance with IEC 62)
- Rated voltage at corresponding maximum temperature
- Date code in accordance with IEC 62
- Name of manufacturer
- Group number (123)
- Code for factory of origin
- Code for basic specification (in accordance with IEC 384-4)
- '+' signs for the positive terminal
- A band to indentify the negative terminal.

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Table 3 apply at T_{amb} = 20 to 25 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz
I_R	= max. RMS ripple current no necessary DC voltage applied
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= max. equivalent series resistance at 100 Hz
Z	= max. impedance at 100 kHz.

Table 3 Electrical data for 123 series

U_R (V)	C_R 100 Hz (μF)	MAXIMUM CASE SIZE ∅D x L (mm)	I_R 100 Hz 125 °C (mA)	I_R 10 kHz 85 °C (mA)	I_R 100 kHz 40 °C (mA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 100 kHz (Ω)
4	68	6.7 x 15.3	53	450	650	14	0.25	7.3	1.2
	100	6.7 x 15.3	77	540	790	20	0.25	5.0	1.2
	220	7.6 x 20.4	160	890	1300	44	0.25	2.3	1.0
	470	9.3 x 23.3	300	1470	2140	94	0.25	1.1	0.4
	1000	10.3 x 32.0	630	2450	3570	200	0.25	0.5	0.3
	1500	12.9 x 32.0	950	3330	4840	300	0.25	0.33	0.2
	2200	12.9 x 32.0	1250	4230	6150	440	0.25	0.23	0.2
6.3	47	6.7 x 15.3	58	440	640	15	0.18	7.6	1.2
	68	6.7 x 15.3	83	520	760	21	0.18	5.3	1.2
	150	7.6 x 20.4	160	870	1270	47	0.18	2.4	1.0
	330	9.3 x 23.3	330	1470	2140	104	0.18	1.1	0.4
	680	10.3 x 32.0	680	2340	3410	214	0.18	0.55	0.3
	1000	12.9 x 32.0	940	3180	4640	315	0.18	0.36	0.2
	1500	12.9 x 32.0	1220	4140	6020	473	0.18	0.24	0.2
10	33	6.7 x 15.3	63	360	530	17	0.18	11	1.2
	47	6.7 x 15.3	83	440	640	24	0.18	7.6	1.2
	68	7.6 x 20.4	110	590	850	34	0.18	5.3	1.0
	100	7.6 x 20.4	160	710	1040	50	0.18	3.6	1.0
	150	9.3 x 23.3	240	990	1450	75	0.18	2.4	0.4
	220	9.3 x 23.3	350	1180	1720	110	0.18	1.7	0.4
	330	10.3 x 32.0	490	1650	2410	165	0.18	1.1	0.3
	470	10.3 x 32.0	570	1940	2830	235	0.18	0.8	0.3
	680	12.9 x 32.0	760	2580	3750	340	0.18	0.55	0.2
	1000	12.9 x 32.0	1000	3380	4920	500	0.18	0.36	0.2

ORDERING INFORMATION

Ordering Example

Electrolytic Capacitors 2222 123 . . . . .
10 µF/16 V, ±20%
Case size 6.7 x 15.3; Form BR
Catalogue number: 2222 123 25109

Table 4 Ordering information for 123 series

U_R (V)	C_R 100 Hz (µF)	MAXIMUM CASE SIZE ∅D x L (mm)	CATALOGUE NUMBER 2222 . . . . [1]			
			SAL-A FORM BA tol. ±20%	SAL-A FORM BR tol. ±20%	SAL-A FORM BA tol. ±10%	SAL-AG FORM BA tol. ±10%, level S
4	68	6.7 x 15.3	123 12689	123 22689	123 42689	123 82689
	100	6.7 x 15.3	123 12101	123 22101	123 42101	123 82101
	220	7.6 x 20.4	123 12221	123 22221	123 42221	123 82221
	470	9.3 x 23.3	123 12471	123 22471	123 42471	123 82471
	1000	10.3 x 32.0	123 12102	123 22102	123 42102	123 82102
	1500	12.9 x 32.0	123 12152	123 22152	123 42152	123 82152
	2200	12.9 x 32.0	123 12222	123 22222	123 42222	123 82222
6.3	47	6.7 x 15.3	123 13479	123 23479	123 43479	123 83479
	68	6.7 x 15.3	123 13689	123 23689	123 43689	123 83689
	150	7.6 x 20.4	123 13151	123 23151	123 43151	123 83151
	330	9.3 x 23.3	123 13331	123 23331	123 43331	123 83331
	680	10.3 x 32.0	123 13681	123 23681	123 43681	123 83681
	1000	12.9 x 32.0	123 13102	123 23102	123 43102	123 83102
	1500	12.9 x 32.0	123 13152	123 23152	123 43152	123 83152
10	33	6.7 x 15.3	123 14339	123 24339	123 44339	123 84339
	47	6.7 x 15.3	123 14479	123 24479	123 44479	123 84479
	68	7.6 x 20.4	123 14689	123 24689	123 44689	123 84689
	100	7.6 x 20.4	123 14101	123 24101	123 44101	123 84101
	150	9.3 x 23.3	123 14151	123 24151	123 44151	123 84151
	220	9.3 x 23.3	123 14221	123 24221	123 44221	123 84221
	330	10.3 x 32.0	123 14331	123 24331	123 44331	123 84331
	470	10.3 x 32.0	123 14471	123 24471	123 44471	123 84471
	680	12.9 x 32.0	123 14681	123 24681	123 44681	123 84681
	1000	12.9 x 32.0	123 14102	123 24102	123 44102	123 84102

U_R (V)	C_R 100 Hz (μF)	MAXIMUM CASE SIZE ∅D x L (mm)	I_R 100 Hz 125 °C (mA)	I_R 10 kHz 85 °C (mA)	I_R 100 kHz 40 °C (mA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 100 kHz (Ω)
16	10	6.7 x 15.3	31	230	330	16	0.14	28	2.5
	15	6.7 x 15.3	47	280	400	24	0.14	19	2.5
	22	6.7 x 15.3	63	340	490	35	0.14	13	2.5
	33	7.6 x 20.4	89	470	680	55	0.14	8.4	2.0
	47	7.6 x 20.4	120	560	810	75	0.14	5.9	2.0
	68	7.6 x 20.4	180	670	970	110	0.14	4.1	2.0
	100	9.3 x 23.3	260	920	1340	160	0.14	2.8	0.8
	150	9.3 x 23.3	310	1060	1550	240	0.16	2.1	0.8
	220	10.3 x 32.0	420	1420	2060	350	0.16	1.5	0.6
	330	10.3 x 32.0	510	1740	2530	500	0.16	1.0	0.6
	470	12.9 x 32.0	680	2280	3330	750	0.16	0.7	0.4
	680	12.9 x 32.0	850	2870	4170	870	0.16	0.5	0.4
20	10	6.7 x 15.3	39	230	330	20	0.14	28	2.5
	15	6.7 x 15.3	52	280	400	30	0.14	19	2.5
	47	7.6 x 20.4	150	560	810	95	0.14	5.9	2.0
	100	9.3 x 23.3	270	920	1340	200	0.14	2.8	0.8
	150	10.3 x 32.0	350	1200	1740	300	0.16	2.1	0.6
	220	10.3 x 32.0	420	1420	2060	400	0.16	1.5	0.6
	330	12.9 x 32.0	570	1910	2780	660	0.16	1.0	0.4
	470	12.9 x 32.0	720	2420	3530	940	0.16	0.7	0.4
25	10	6.7 x 15.3	43	230	330	25	0.14	28	5
	15	6.7 x 15.3	60	280	400	35	0.14	19	5
	22	7.6 x 20.4	88	370	550	55	0.14	13	2.5
	33	7.6 x 20.4	130	470	680	85	0.14	8.4	2.5
	47	7.6 x 20.4	160	560	810	100	0.14	5.9	2.5
	68	9.3 x 23.3	230	760	1110	170	0.14	4.1	1.0
	100	9.3 x 23.3	250	860	1250	250	0.16	3.2	1.0
	150	10.3 x 32.0	350	1200	1740	400	0.16	2.1	0.8
	220	12.9 x 32.0	460	1560	2270	550	0.16	1.5	0.6
	330	12.9 x 32.0	600	2030	2950	800	0.16	1.0	0.6

U_R (V)	C_R 100 Hz (µF)	MAXIMUM CASE SIZE ∅D x L (mm)	CATALOGUE NUMBER 2222 . . . . [1]			
			SAL-A FORM BA tol. ±20%	SAL-A FORM BR tol. ±20%	SAL-A FORM BA tol. ±10%	SAL-AG FORM BA tol. ±10%, level S
16	10	6.7 x 15.3	123 15109	123 25109	123 45109	123 85109
	15	6.7 x 15.3	123 15159	123 25159	123 45159	123 85159
	22	6.7 x 15.3	123 15229	123 25229	123 45229	123 85229
	33	7.6 x 20.4	123 15339	123 25339	123 45339	123 85339
	47	7.6 x 20.4	123 15479	123 25479	123 45479	123 85479
	68	7.6 x 20.4	123 15689	123 25689	123 45689	123 85689
	100	9.3 x 23.3	123 15101	123 25101	123 45101	123 85101
	150	9.3 x 23.3	123 15151	123 25151	123 45151	123 85151
	220	10.3 x 32.0	123 15221	123 25221	123 45221	123 85221
	330	10.3 x 32.0	123 15331	123 25331	123 45331	123 85331
	470	12.9 x 32.0	123 15471	123 25471	123 45471	123 85471
	680	12.9 x 32.0	123 15681	123 25681	123 45681	123 85681
20	10	6.7 x 15.3	123 18109	123 28109	123 48109	123 88109
	15	6.7 x 15.3	123 18159	123 28159	123 48159	123 88159
	47	7.6 x 20.4	123 18479	123 28479	123 48479	123 88479
	100	9.3 x 23.3	123 18101	123 28101	123 48101	123 88101
	150	10.3 x 32.0	123 18151	123 28151	123 48151	123 88151
	220	10.3 x 32.0	123 18221	123 28221	123 48221	123 88221
	330	12.9 x 32.0	123 18331	123 28331	123 48331	123 88331
	470	12.9 x 32.0	123 18471	123 28471	123 48471	123 88471
25	10	6.7 x 15.3	123 16109	123 26109	123 46109	123 86109
	15	6.7 x 15.3	123 16159	123 26159	123 46159	123 86159
	22	7.6 x 20.4	123 16229	123 26229	123 46229	123 86229
	33	7.6 x 20.4	123 16339	123 26339	123 46339	123 86339
	47	7.6 x 20.4	123 16479	123 26479	123 46479	123 86479
	68	9.3 x 23.3	123 16689	123 26689	123 46689	123 86689
	100	9.3 x 23.3	123 16101	123 26101	123 46101	123 86101
	150	10.3 x 32.0	123 16151	123 26151	123 46151	123 86151
	220	12.9 x 32.0	123 16221	123 26221	123 46221	123 86221
	330	12.9 x 32.0	123 16331	123 26331	123 46331	123 86331

U_R (V)	C_R 100 Hz (μF)	MAXIMUM CASE SIZE ØD x L (mm)	I_R 100 Hz 125 °C (mA)	I_R 10 kHz 85 °C (mA)	I_R 100 kHz 40 °C (mA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 100 kHz (Ω)
35	1.0	6.7 x 15.3	4	55	80	5	0.12	240	16.5
	1.5	6.7 x 15.3	7	68	98	5	0.12	160	11.0
	2.2	6.7 x 15.3	10	82	120	5	0.12	109	7.5
	3.3	6.7 x 15.3	14	100	150	7	0.12	73	7.5
	4.7	6.7 x 15.3	20	120	170	10	0.12	51	7.5
	6.8	6.7 x 15.3	27	140	210	15	0.12	35	7.5
	10	7.6 x 20.4	37	200	280	20	0.12	24	2.5
	15	7.6 x 20.4	53	240	350	30	0.12	16	2.5
	22	7.6 x 20.4	78	290	420	45	0.12	11	2.5
	33	9.3 x 23.3	120	410	590	65	0.12	7.2	1.0
	47	9.3 x 23.3	140	480	700	95	0.12	5.1	1.0
	68	10.3 x 32.0	170	570	820	135	0.16	4.7	0.8
	100	12.9 x 32.0	220	760	1100	200	0.16	3.2	0.6
	150	12.9 x 32.0	290	990	1440	300	0.16	2.1	0.6
40	2.2	6.7 x 15.3	11	82	120	9	0.12	109	7.5
	3.3	6.7 x 15.3	16	100	150	13	0.12	73	7.5
	4.7	6.7 x 15.3	22	120	170	19	0.12	51	7.5
	6.8	6.7 x 15.3	28	140	210	27	0.12	35	7.5
	10	7.6 x 20.4	41	200	280	40	0.12	24	2.5
	15	7.6 x 20.4	61	240	350	60	0.12	16	2.5
	22	9.3 x 23.3	89	330	480	90	0.12	11	1.5
	33	9.3 x 23.3	120	410	590	130	0.12	7.2	1.0
	47	10.3 x 32.0	160	540	790	190	0.12	5.1	1.0
	68	10.3 x 32.0	170	570	820	270	0.16	4.7	0.8
	100	12.9 x 32.0	220	760	1100	400	0.16	3.2	0.6

U_R (V)	C_R 100 Hz (μF)	MAXIMUM CASE SIZE ∅D x L (mm)	CATALOGUE NUMBER 2222 . . . . [1]			
			SAL-A FORM BA tol. ±20%	SAL-A FORM BR tol. ±20%	SAL-A FORM BA tol. ±10%	SAL-AG FORM BA tol. ±10%, level S
35	1.0	6.7 x 15.3	123 10108	123 20108	123 40108	123 80108
	1.5	6.7 x 15.3	123 10158	123 20158	123 40158	123 80158
	2.2	6.7 x 15.3	123 10228	123 20228	123 40228	123 80228
	3.3	6.7 x 15.3	123 10338	123 20338	123 40338	123 80338
	4.7	6.7 x 15.3	123 10478	123 20478	123 40478	123 80478
	6.8	6.7 x 15.3	123 10688	123 20688	123 40688	123 80688
	10	7.6 x 20.4	123 10109	123 20109	123 40109	123 80109
	15	7.6 x 20.4	123 10159	123 20159	123 40159	123 80159
	22	7.6 x 20.4	123 10229	123 20229	123 40229	123 80229
	33	9.3 x 23.3	123 10339	123 20339	123 40339	123 80339
	47	9.3 x 23.3	123 10479	123 20479	123 40479	123 80479
	68	10.3 x 32.0	123 10689	123 20689	123 40689	123 80689
	100	12.9 x 32.0	123 10101	123 20101	123 40101	123 80101
	150	12.9 x 32.0	123 10151	123 20151	123 40151	123 80151
40	2.2	6.7 x 15.3	123 17228	123 27228	123 47228	123 87228
	3.3	6.7 x 15.3	123 17338	123 27338	123 47338	123 87338
	4.7	6.7 x 15.3	123 17478	123 27478	123 47478	123 87478
	6.8	6.7 x 15.3	123 17688	123 27688	123 47688	123 87688
	10	7.6 x 20.4	123 17109	123 27109	123 47109	123 87109
	15	7.6 x 20.4	123 17159	123 27159	123 47159	123 87159
	22	9.3 x 23.3	123 17229	123 27229	123 47229	123 87229
	33	9.3 x 23.3	123 17339	123 27339	123 47339	123 87339
	47	10.3 x 32.0	123 17479	123 27479	123 47479	123 87479
	68	10.3 x 32.0	123 17689	123 27689	123 47689	123 87689
	100	12.9 x 32.0	123 17101	123 27101	123 47101	123 87101

Note

[1] The 8th digit of the catalogue number represents the tolerance, as follows:

TOLERANCE	SAL-A		SAL-AG	
	FORM BA	FORM BR	FORM BA	FORM BA, level S
±20% : 2222	123 1....	123 2....	123 6....	–
±10% : 2222	123 4....	123 5....	123 7....	123 8....

Voltage

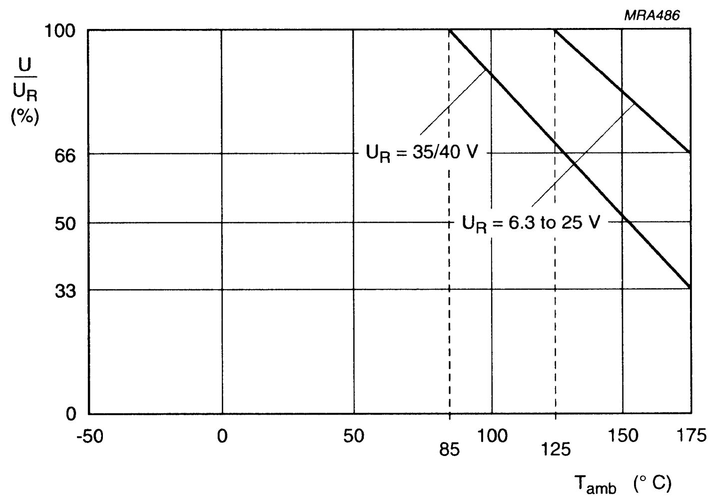


Fig.3 Max. permissible voltage up to 175 °C.

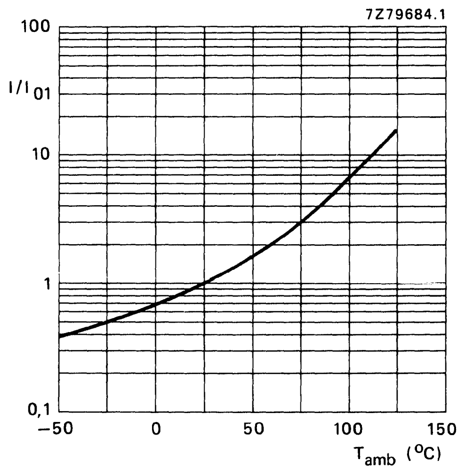
Surge voltage for short periods	$U_s \leq 1.15 \bullet U_R$	
Reverse voltage	$U_{rev} < 0.3 \bullet U_R$	
Max. peak AC voltage, reverse voltage applied	≤2 V	
Max. peak AC voltage, without reverse voltage applied		
	T_{amb} ≤85 °C	85 °C < T_{amb} ≤125 °C
at f ≤ 0.1 Hz	0.30 x U_R	0.15 x U_R
at 0.1 Hz < f ≤ 1 Hz	0.45 x U_R	0.22 x U_R
at 1 Hz < f ≤ 10 Hz	0.60 x U_R	0.30 x U_R
at 10 Hz < f ≤ 50 Hz	0.65 x U_R	0.32 x U_R
at f > 50 Hz	0.80 x U_R	0.40 x U_R

Ripple current (I_R)

Applying the max. RMS ripple current given in Table 3 will cause a device temperature of 138 °C. The 100 kHz values in Table 3 for other temperatures are to be calculated with the following I_R multipliers:

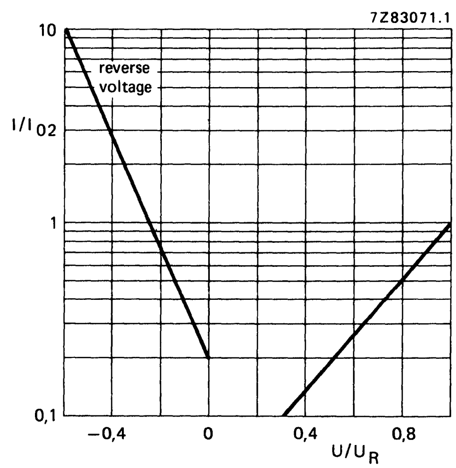
T_{amb}	25 °C	40 °C	65 °C	85 °C	105 °C	125 °C
I_R multiplier	1.1	1.0	0.88	0.75	0.59	0.37

Leakage current



I_{01} = leakage current during continuous operation at U_R and T_{amb} = 25 °C.

Fig.4 Typical multiplier of leakage current (I/I_{01}) as a function of ambient temperature.

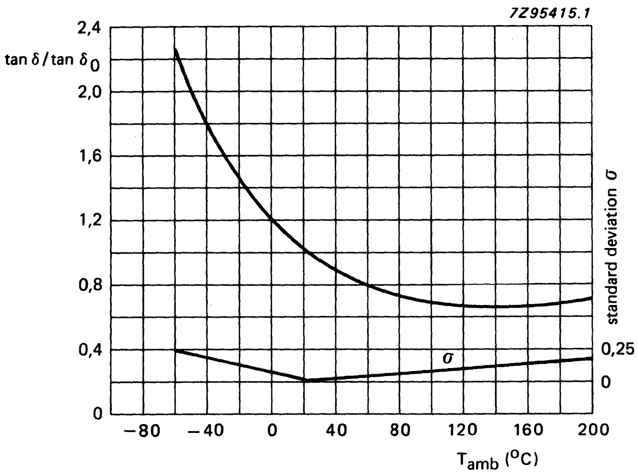


I_{02} = leakage current at U_R at a discrete constant temperature.

Fig.5 Typical multiplier of leakage current (I/I_{02}) as a function of U/U_R.

Maximum leakage current after 5 minutes at U_R and T_{amb} = 25 °C	$I_{L5} \leq 0.05\ C_R \times U_R$ or 2 µA whichever is greater, (see Table 3)
Typical leakage current 15 s at U_R and T_{amb} = 25 °C	
6.3 to 16 V versions	approx. 0.2 x value stated in Table 3
25 to 40 V versions	approx. 0.1 x value stated in Table 3

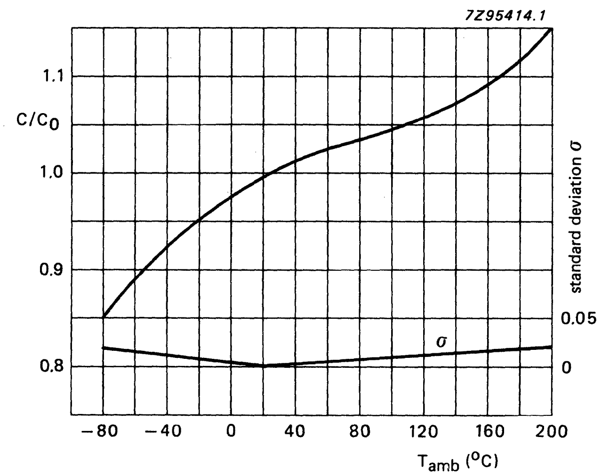
Dissipation factor (tan δ)



tan δ_0 = dissipation factor at T_{amb} = 25 °C and 100 Hz.

Fig.6 Typical multiplier of dissipation factor (tan δ/tan δ_0) as a function of ambient temperature.

Capacitance (C)



C_0 = capacitance at 25 °C and 100 Hz.

Fig.7 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature.

Typical tan δ at 100 Hz and T_{amb} = 25 °C: 0.6 x value stated in Table 3.

Max Power dissipation

CASE SIZE $\varnothing D_{max} \times L_{max}$	$P_{max}(W) = P_{125}$
Ø6.7 x 15.3	0.13
Ø7.6 x 20.4	0.16
Ø9.3 x 23.3	0.21
Ø10.3 x 32.0	0.26
Ø12.9 x 32.0	0.32

Equivalent series inductance (ESL), f = 10 MHz

CASE SIZE $\varnothing D_{max} \times L_{max}$	PITCH (mm)	MAX. ESL (nH)	TYP. ESL (nH)
Ø6.7 x 15.3	20.3	30	15 to 23
Ø7.6 x 20.4	25.4	30	16 to 24
Ø9.3 x 23.3	27.9	35	20 to 27
Ø10.3 x 32.0	35.6	40	26 to 33
Ø12.9 x 32.0	35.6	55	32 to 49

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Equivalent series resistance (ESR)

Typical ESR: see Figs 8 to 17; the standard deviation is 20% of each value.

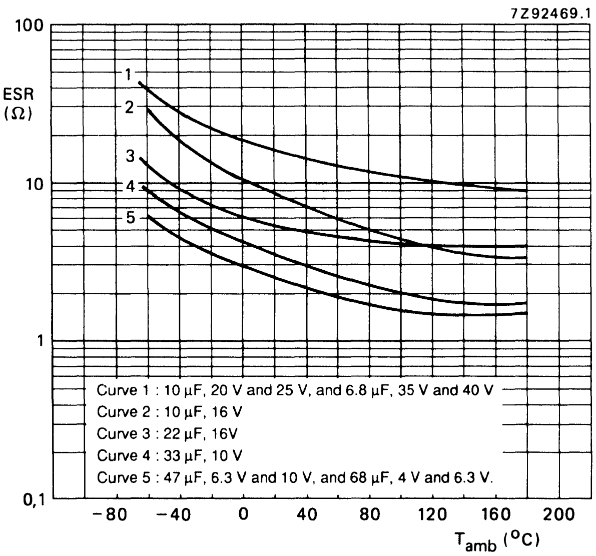


Fig.8 Typical ESR as a function of ambient temperature at 100 Hz, case size Ø6.7 x 15.3.

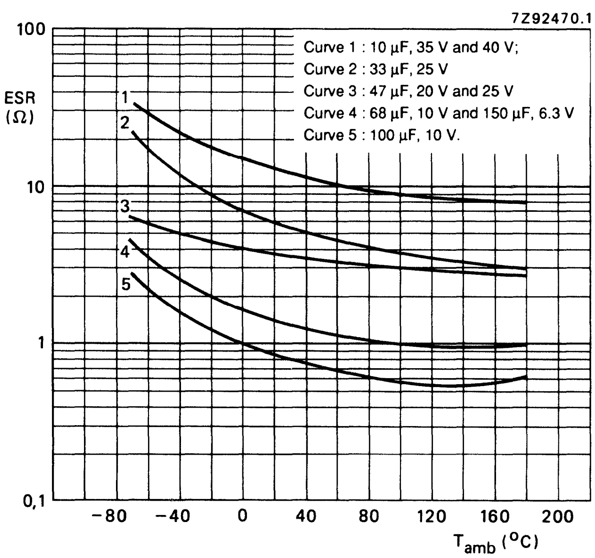


Fig.9 Typical ESR as a function of ambient temperature at 100 Hz, case size Ø7.6 x 20.4.

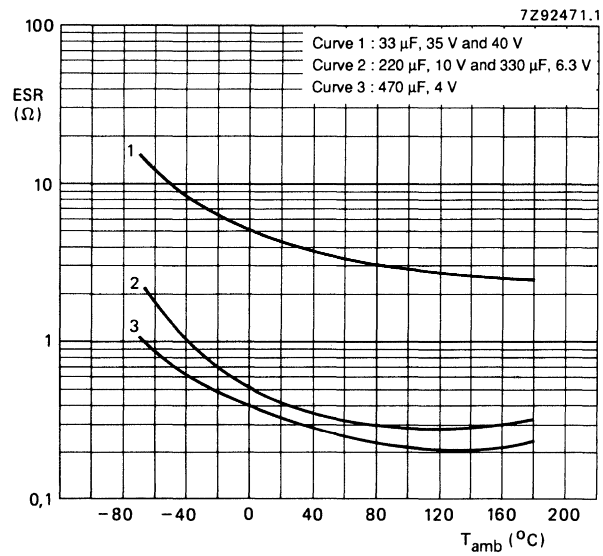


Fig.10 Typical ESR as a function of ambient temperature at 100 Hz, case size ∅9.3 x 23.3.

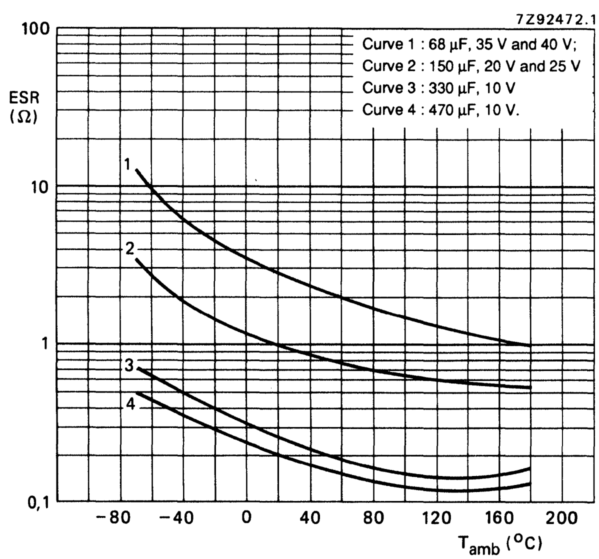


Fig.11 Typical ESR as a function of ambient temperature at 100 Hz, case size ∅10.3 x 32.0.

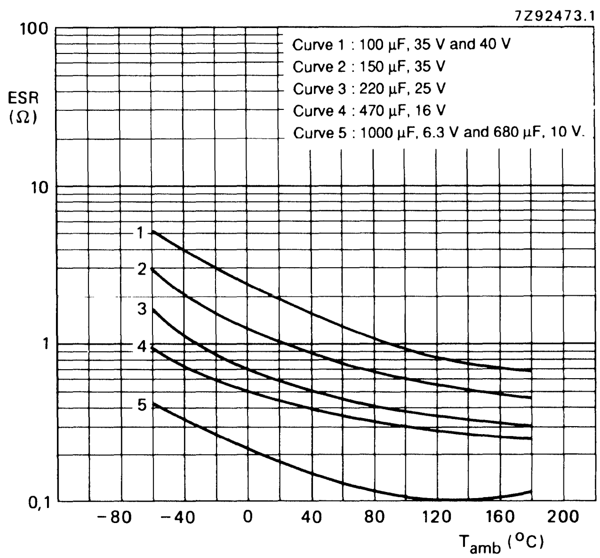


Fig.12 Typical ESR as a function of ambient temperature at 100 Hz, case size Ø12.9 x 32.0.

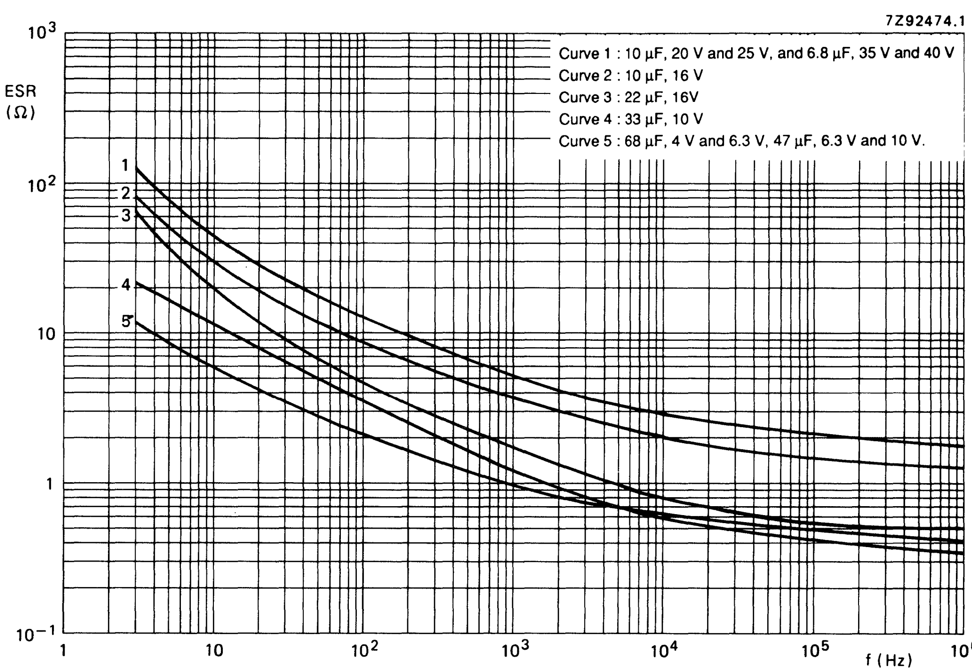


Fig.13 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size Ø6.7 x 15.3.

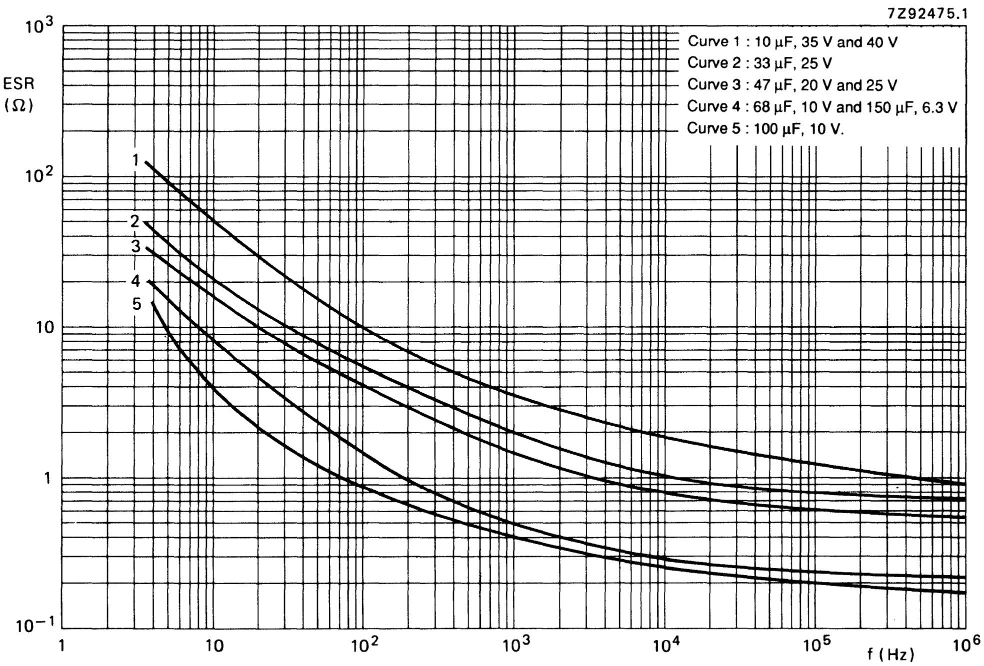


Fig.14 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size ∅7.6 x 20.4.

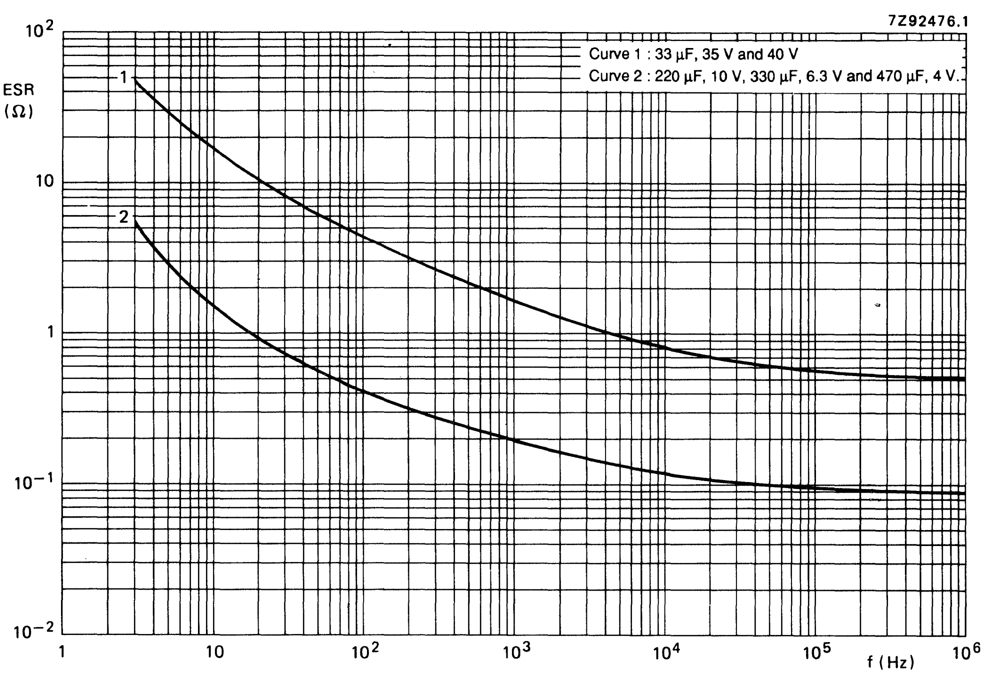


Fig.15 Typical ESR as a function of frequency at T_{amb} = 25 °; case size ∅9.3 x 23.3.

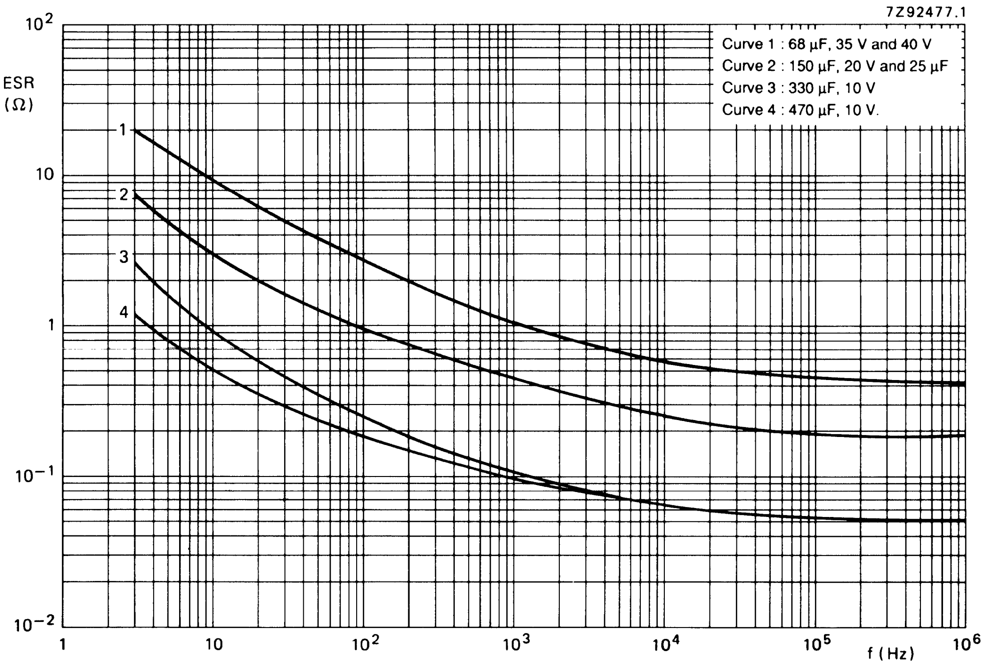


Fig.16 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size ∅10.3 x 32.0.

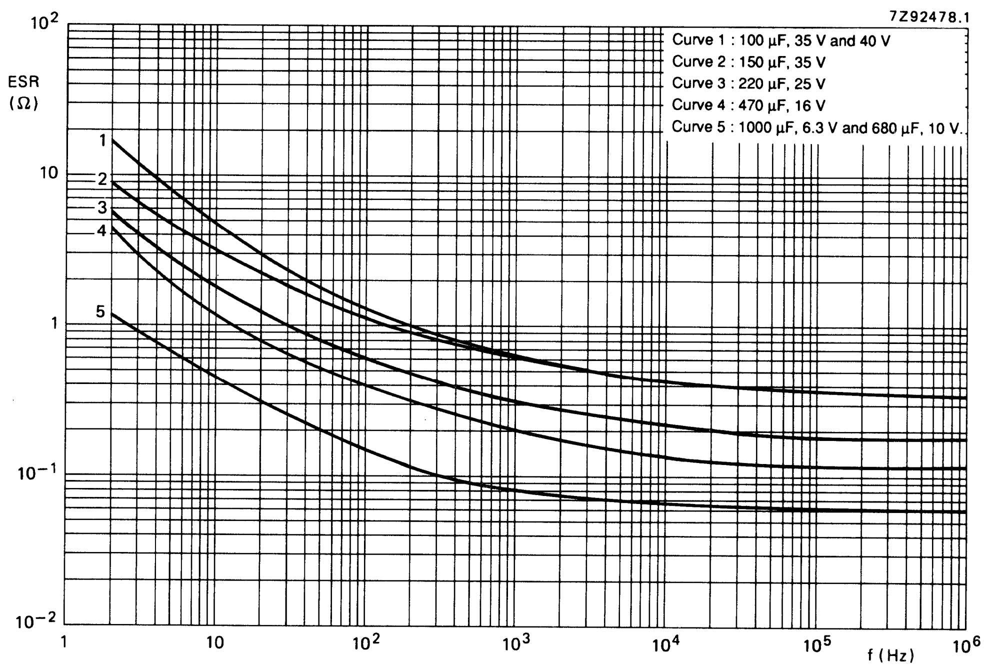
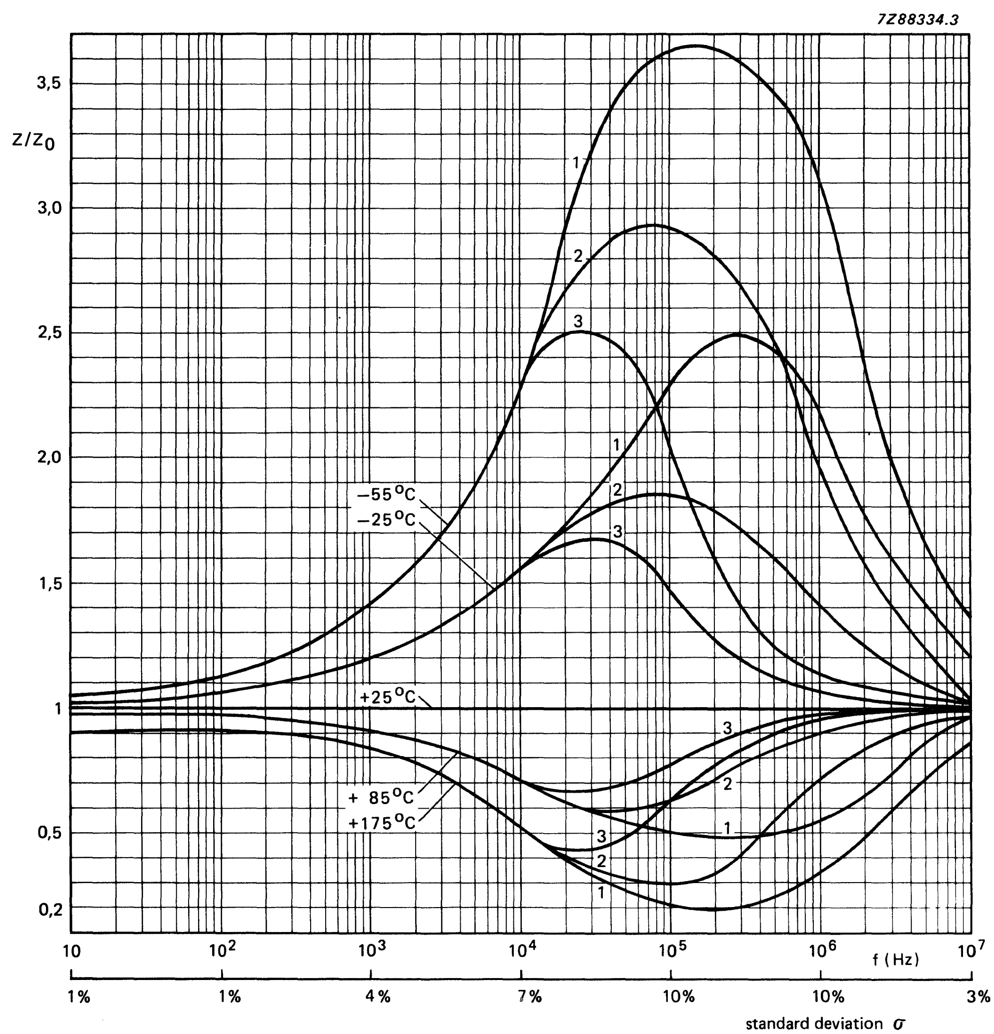


Fig.17 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size ∅12.9 x 32.0.

Impedance (Z)

Typical impedance at 100 kHz and T_{amb} = 25 °C: 0.5 x value stated in Table 3 .



Curve 1 : case sizes ∅6.7 x 15.3 and ∅7.6 x 20.4, 16 V to 40 V

Curve 2 : case size ∅6.7 x 15.3 and ∅7.6 x 20.4, 4 V to 10 V

Curve 3 : case sizes ∅9.3 x 32.0, ∅10.3 x 32.0 and ∅12.9 x 32.0.

Z_0 = initial impedance value at any frequency and T_{amb} = 25 °C.

Fig.18 Typical multiplier of impedance (Z/Z_0) as a function of frequency at different ambient temperatures.

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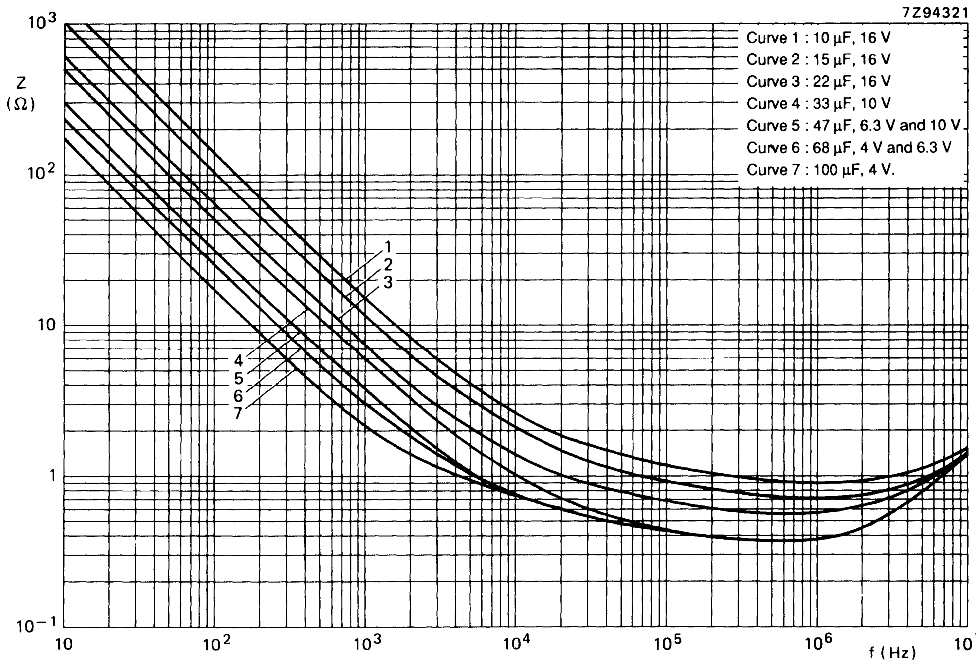

Fig.19 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size ∅6.7 x 15.3, U_R = 4 V to 16 V.

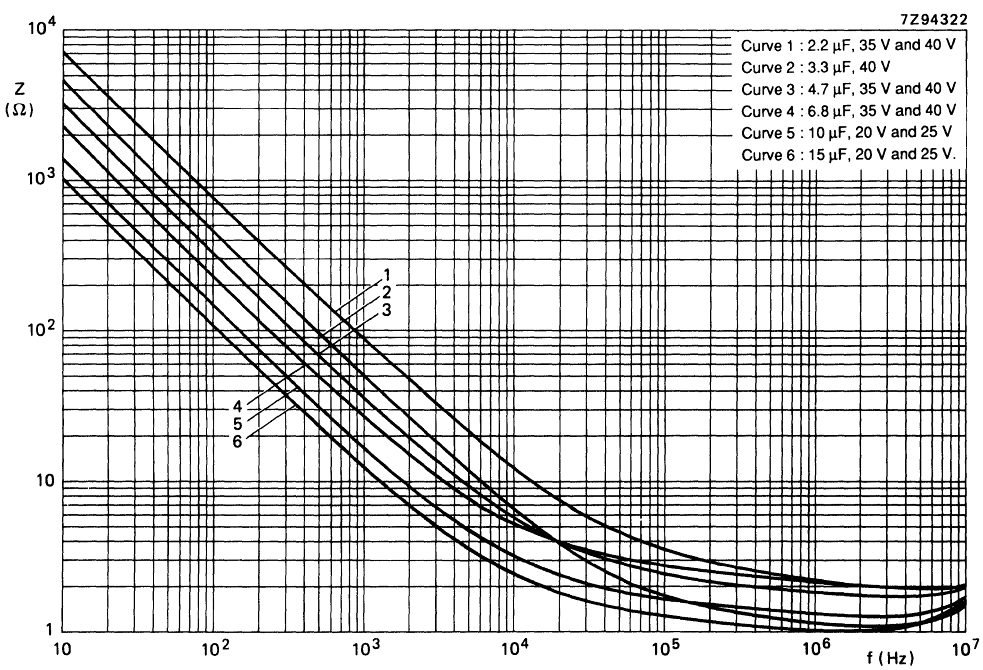

Fig.20 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size ∅6.7 x 15.3, U_R = 20 V to 40 V.

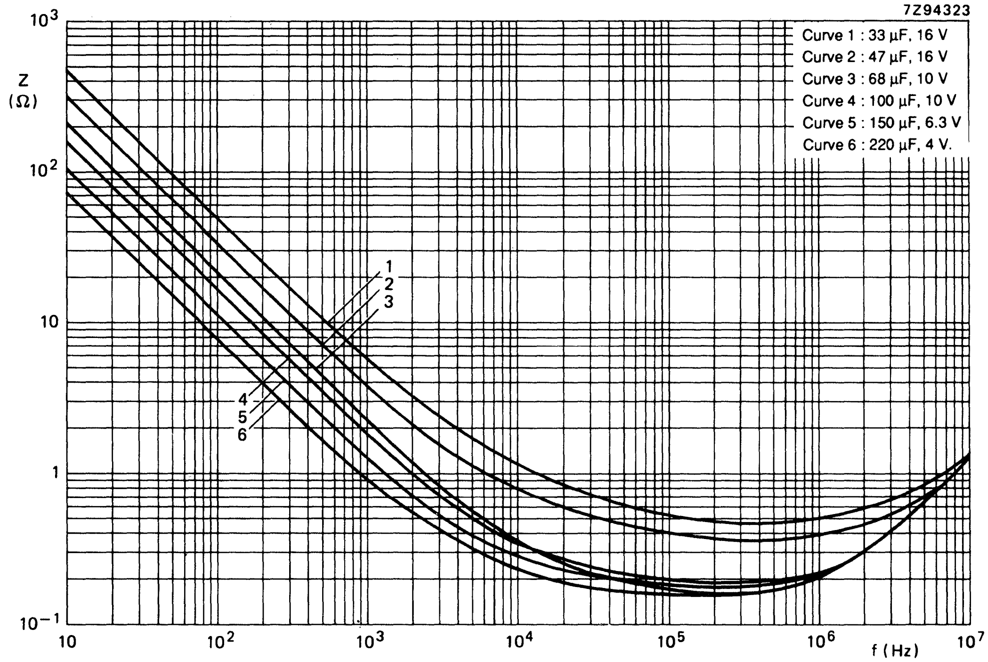

Fig.21 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size Ø7.6 x 20.4, U_R = 4 V to 16 V.

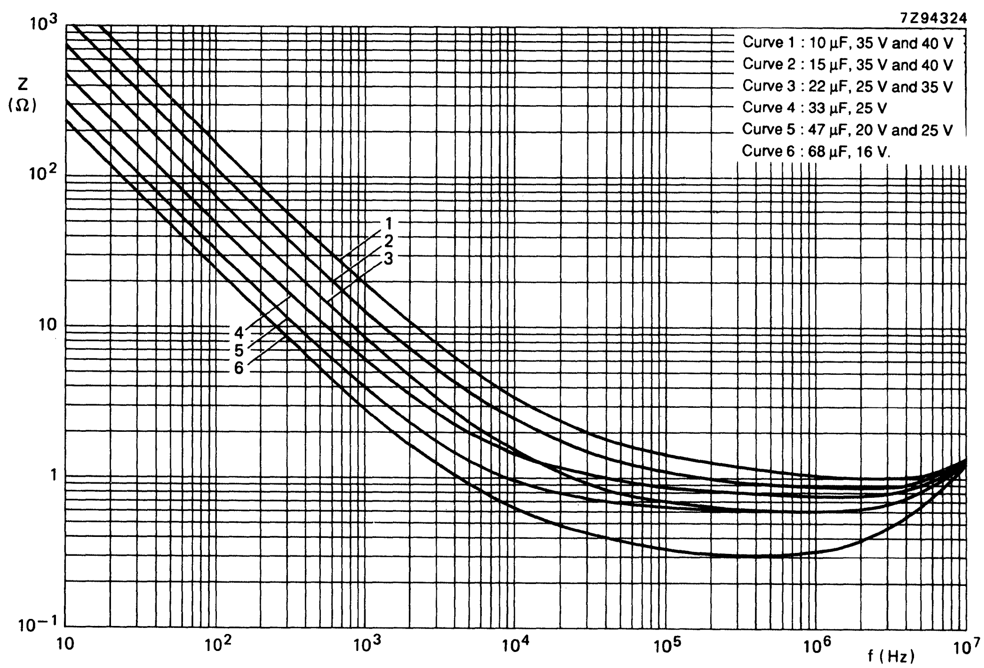

Fig.22 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size Ø7.6 x 20.4, U_R = 16 V to 40 V.

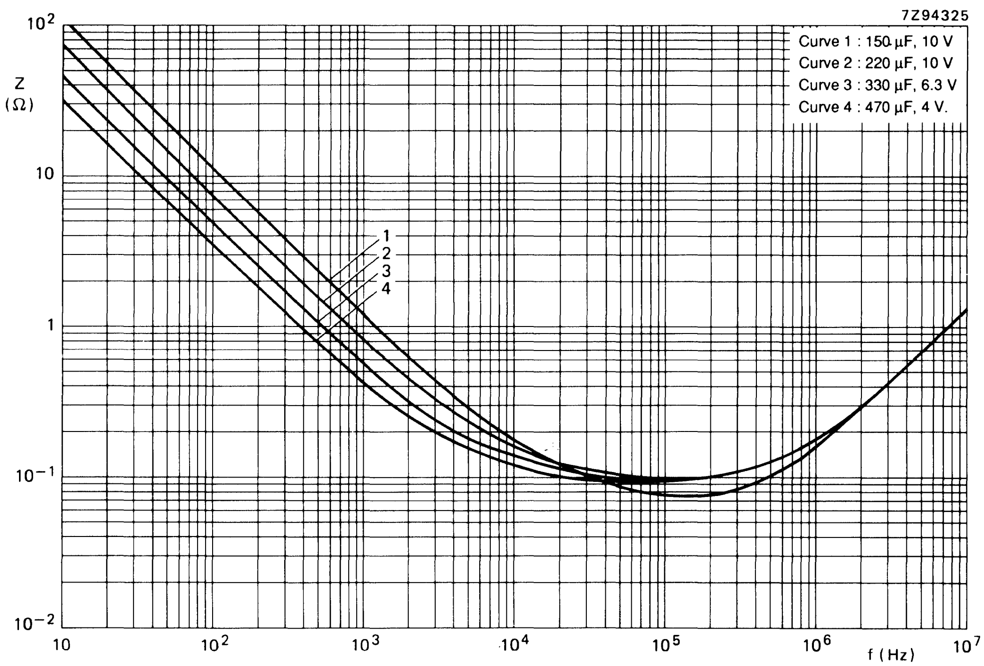

Fig.23 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size ∅9.3 x 23.3, U_R = 4 V to 10 V.

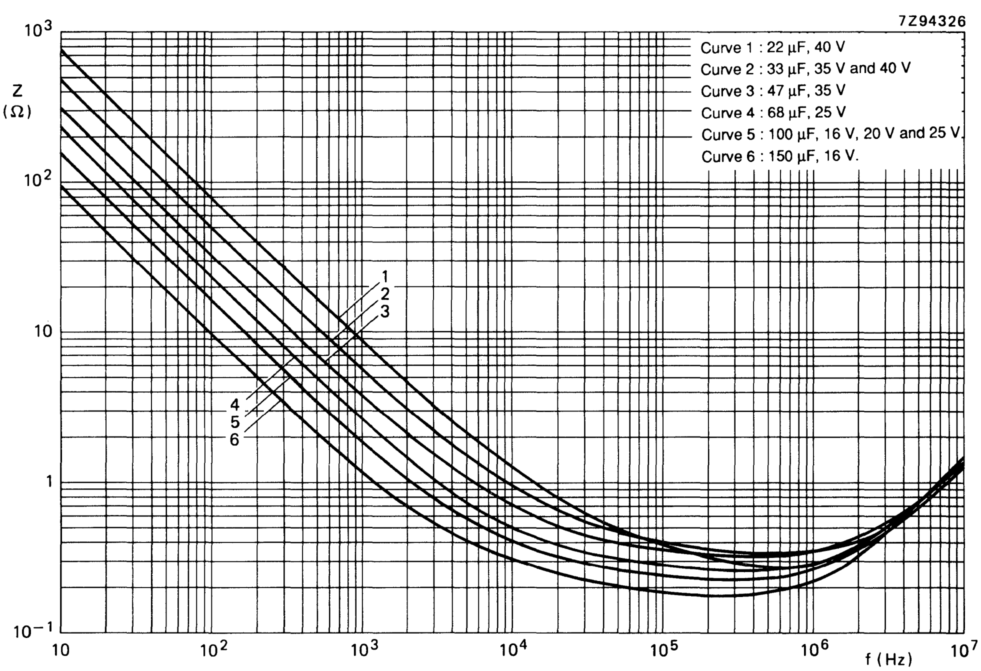

Fig.24 Typical impedance as a function of frequency at T_{amb} = 25 °C;
case size ∅9.3 x 23.3, U_R = 16 V to 40 V.

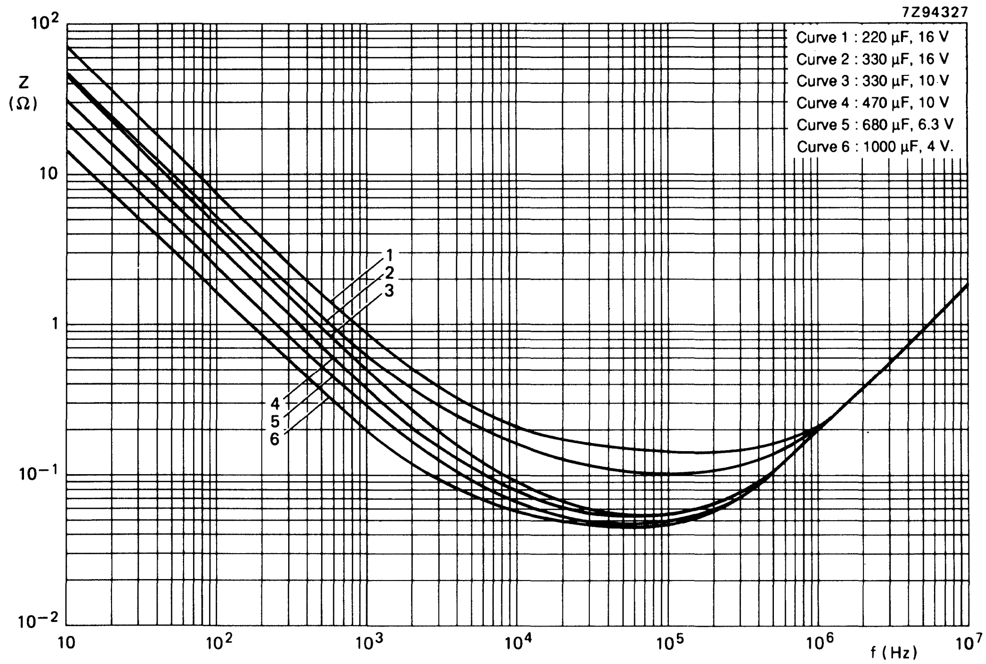

Fig.25 Typical impedance as a function of frequency at T_{amb} = 25 °C;
case size ∅10.3 x 32.0, U_R = 4 V to 16 V.

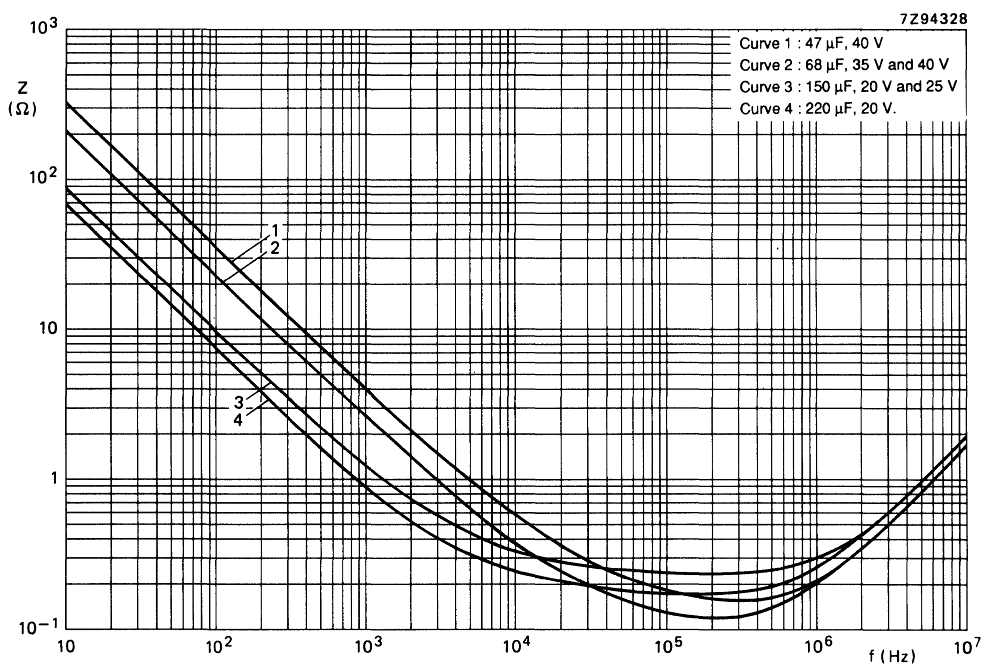

Fig.26 Typical impedance as a function of frequency at T_{amb} = 25 °C;
case size ∅10.3 x 32.0, U_R = 20 V to 40 V.

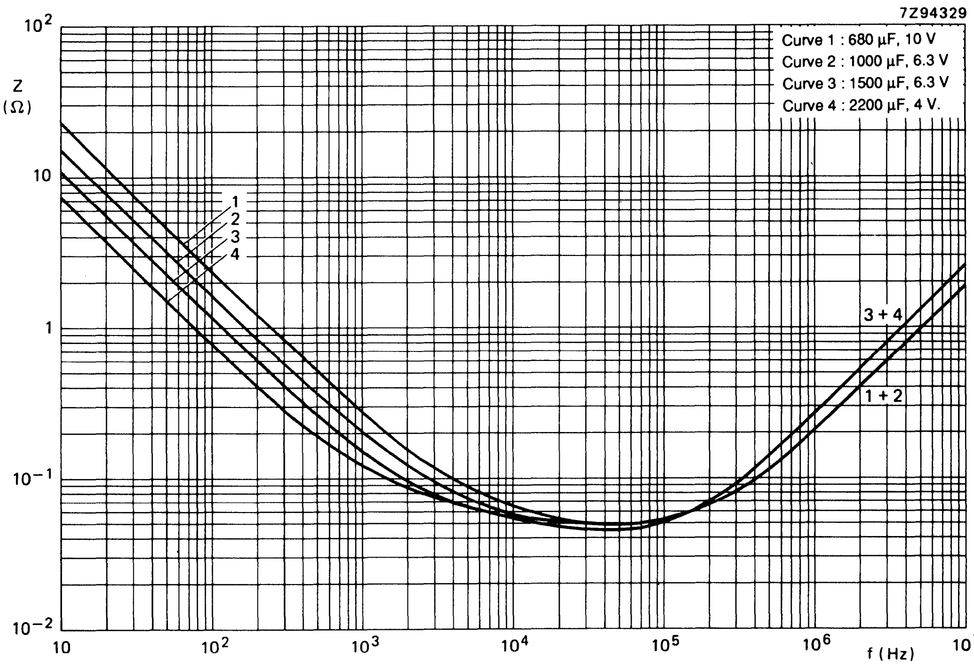

Fig.27 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size ∅12.9 x 32.0, U_R = 4 V to 10 V.

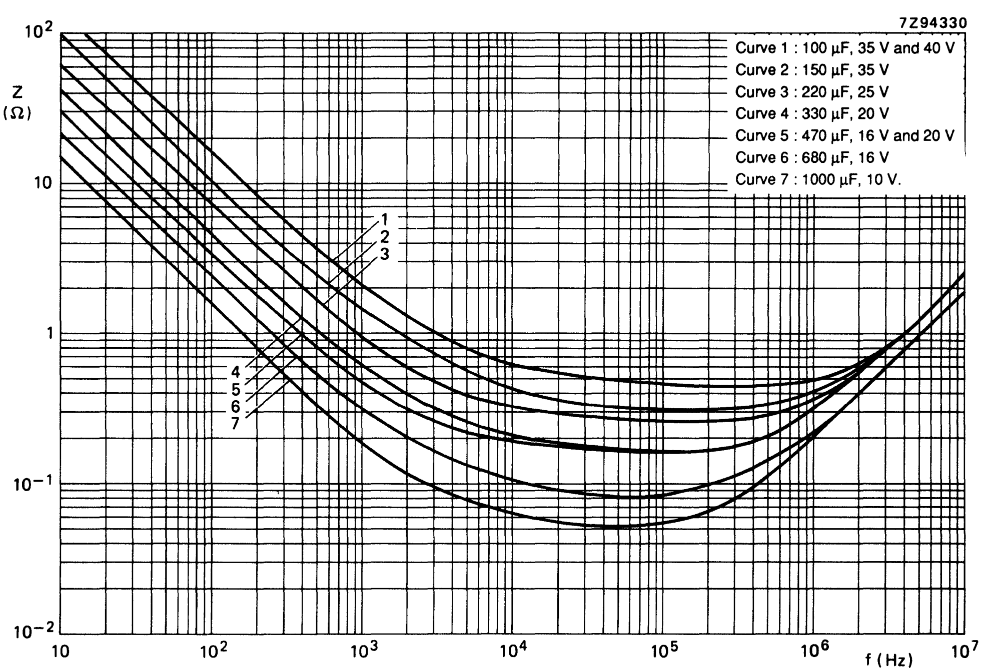

Fig.28 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size ∅12.9 x 32.0, U_R = 10 V to 40 V.

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements".

Table 5

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	Reference		
Endurance	IEC 384-4-2/ CECC 30 302 group C3, 4.13	T_{amb} = 125 °C U_R = 6.3 to 25 V with U_R applied U_R = 35 and 40 V with U_C applied 10 000 hours	$\Delta C/C$ $\leq\pm10\%$ tan δ $\leq$1.2 x spec. limit Z $\leq$1.2 x spec. limit I_{L5} $\leq$spec. limit
Useful life	CECC 30 302 amendment 2642 sub clause 1.8.1	T_{amb} = 125 °C, I_R applied and U_R = 6.3 to 25 V with U_R applied U_R = 35 and 40 V with U_C applied 20 000 hours	$\Delta C/C$ $\leq15\%$ tan δ $\leq$1.5 x spec. limit Z $\leq$1.5 x spec. limit I_{L5} $\leq$spec. limit no short or open circuit no visible damage total failure percentage <1%
Shelf life (storage at high temp.)	IEC 384-4-2/ CECC 30 302 group C 5a, 4.17	T_{amb} = 125 °C, no voltage applied 500 hours	$\Delta C/C$ $\leq\pm10\%$ tan δ $\leq$1.2 x spec. limit I_{L5} $\leq$1 x spec. limit
Charge and discharge	IEC 384-4-2 sub clause 9.21	10^6 cycles without series resistance 0.5 s to U_R 0.5 s to ground	$\Delta C/C$ $\leq5\%$ no short or open circuit no visible damage
Extended vibration test	IEC 68-2-6 test Fc	10 to 2 000 Hz 1.5 mm or 20 g 1 octave/minute 3 directions 1 sweep per direction no voltage applied	no intermittent contacts; no breakdown; no open circuiting; no mechanical damage; $\Delta C/C$ $\leq5\%$ tan δ $\leq$1.2 x spec. limit Z $\leq$1.2 x spec. limit I_{L5} $\leq$1.5 x spec. limit
Shock test	IEC 68-2-27 test Ea	half-sine or saw tooth pulse shape 50 g, 11 ms, 3 successive shocks in each direction of 3 mutually perpendicular axes, no voltage applied	no intermittent contacts; no breakdown; no open circuiting; no mechanical damage; $\Delta C/C$ <5% tan δ $\leq$1.2 x spec. limit Z $\leq$1.2 x spec. limit I_{L5} $\leq$1.5 x spec. limit
Severe rapid change of temperature		100 cycles of 15 minutes at −40 °C and +125 °C	$\Delta C/C$ $\leq\pm10\%$ tan δ $\leq$1.6 x spec. limit Z $\leq$1.6 x spec. limit I_{L5} $\leq$1 x spec.limit

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TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Solvent resistance test	IEC 68-2-45, IEC 653 test XA	sequence: - 30 s vapour phase - 5 minutes ultrasonic immersion at ambient temperature - 30 s vapour phase Solvents: - deionized water (50 ±5 °C); - calgonite solution (20 g/l, 70 ±5 °C); - 1.1.1.-trichloro-ethane; - mixtures of 1.1.2.-trichloro-1.2.2.-trifluoro-ethane (fluorocarbon 113) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon; * ARKLONE K; 75% w/w F113 and 25% w/w isopropanol * FREON TE; 95.5% w/w F113 and 4.5% w/w ethanol * FREON TMS; 94% w/w F113, 5.7% w/w methanol and 0.3% w/w nitro-methane *ARKLONE F; 95.6% w/w F113, 4.0% w/w ethylalcohol, 0.07% w/w stabilizer and 0.3% w/w special additives * ARKLONE A-M; 94.15% w/w F113, 3.7% w/w ethylalcohol, 2.1% w/w methylacetate and 0.05% w/w stabilizer	visual appearance not affected
Passive flammability test	IEC 695-2-2	capacitor mounted to a vertical printed-wiring board, one flame on capacitor body, T_{amb} = 20 to 25 °C, test duration = 20 s.	after removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample

Notes

1. ARKLONE is a trade mark of I.C.I.
2. FREON is a trade mark of Dupont de Nemours.

ADDITIONAL TESTS and REQUIREMENTS for Epoxy-filled versions SAL - AG

2222 123 6.... Form BA ±20%
2222 123 7.... Form BA ±10%
2222 123 8.... Form BA ±10%, level S

Severe vibration tests, in accordance with IEC 68-2-6 and MIL STD-202, method 204, letters E, with the following details and additions:		
Method of mounting: severity 1 severity 2 severity 1 and 2	clamping both body and leads. frequency range temp. 10-3000 Hz; 20-25 °C frequency range temp. 50-2000 Hz; 125 °C vibration amplitude: 50 g or 3.5 mm, whichever is less.	
Direction and duration of motion: severity 1 severity 2	 1 octave/minute, 3 directions (mutually perpendicular), 20 sweeps per direction (total 60 sweeps or 18 hours) 1 octave/minute, 2 directions (longitudinal and transversal), 3 sweeps per direction (total 6 sweeps or 1 hour).	
Functioning: severity 1 severity 2	 rated voltage applied no voltage applied	
Requirements:	$\Delta C/C$:	≤10%
	tan δ:	≤1.2 x stated limit
	Z:	≤1.4 x stated limit
	DC leakage current:	≤stated limit
	general:	no intermittent contacts no indication of breakdown no open circuiting no evidence of mechanical damage.
Typical capability: up to 80 g at 10 to 3000 Hz (also at 125 °C).		
Severe shock tests, in accordance with IEC 68-2-27 and MIL STD-202, method 213, letter F, with the following details and additions		
Method of mounting: Pulse shape: severity 1: severity 2: severity 3:	clamping both body and leads. half-sine or sawtooth. 1500 g, 0.5 ms (MIL STD-202, method 213, letter F) 3000 g, 0.2 ms 10 000 g, 0.1 ms.	
Direction and number of shocks: severity 1 and 2: severity 3:	 3 sucessive shocks in each direction of 3 mutually perpendicular axes (total 18 shocks) 1 shock in any direction.	
Functioning:	rated voltage applied.	
Requirements: Typical capability:	see "severe vibration tests" (as above) ≥100 000 g; these shock tests can be preceded by severe vibration tests on the same samples.	

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NOTES

FEATURES

- Polarized aluminium electrolytic capacitors, solid electrolyte MnO_2
- Radial leads, max. height 9.5 mm, resin dipped, orange coloured
- Extremely long useful life, 20 000 hours/125 °C
- Extended usable temperature range up to 175 °C
- Excellent low temperature, impedance and ESR behaviour
- Charge and discharge proof, application with 0 Ω resistance allowed
- Reverse DC voltage up to 0.3 x U_R allowed
- AC voltage up to 0.8 x U_R allowed
- Advanced technology to achieve high reliability and high stability.

APPLICATIONS

- EDP, telecommunication, general industrial, automotive and audio-video
- Smoothing, filtering and buffering
- For small power supplies, DC/DC converters.

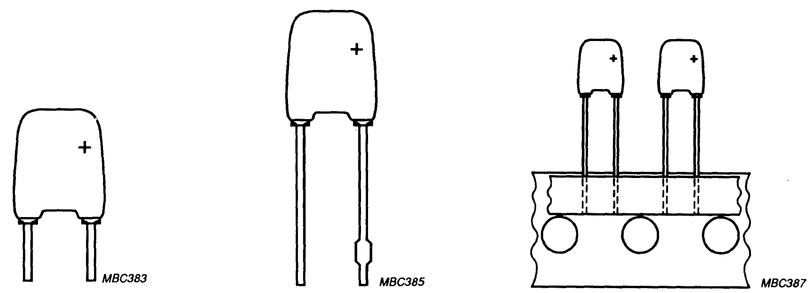


Fig.1 Component outlines.

QUICK REFERENCE DATA

Case sizes (H_{max} x W_{max} x T_{max} in mm)	9.5 x 7 x 3 to 9.5 x 8 x 6
Rated capacitance range (E6 series), C_R	0.1 to 68 μF
Tolerance on C_R	±20%, ±10% to special order
Rated voltage range, U_R	6.3 to 40 V
Category temperature range for U_R = 6.3 to 25 V for U_R = 35 and 40 V for U_C = 35 and 40 V	 −55 to +125 °C −55 to +85 °C −55 to +125 °C
Endurance test at 125 °C	10 000 hours
Useful life at 125 °C	20 000 hours
Useful life at 175 °C	2000 hours
Useful life at 40 °C, I_R applied	>300 000 hours
Shelf life at 0 V, 125 °C	500 hours
Basic specifications	IEC 384-4/CECC 30 300
Climatic category IEC 68 DIN 40040 NF C20-600	 55/125/56 FKD 434
Approval	CECC 30 302 - 005

Table 1 Selection chart for C_R, U_R, U_C and relevant maximum case sizes **(H x W x T in mm)** for 128 series

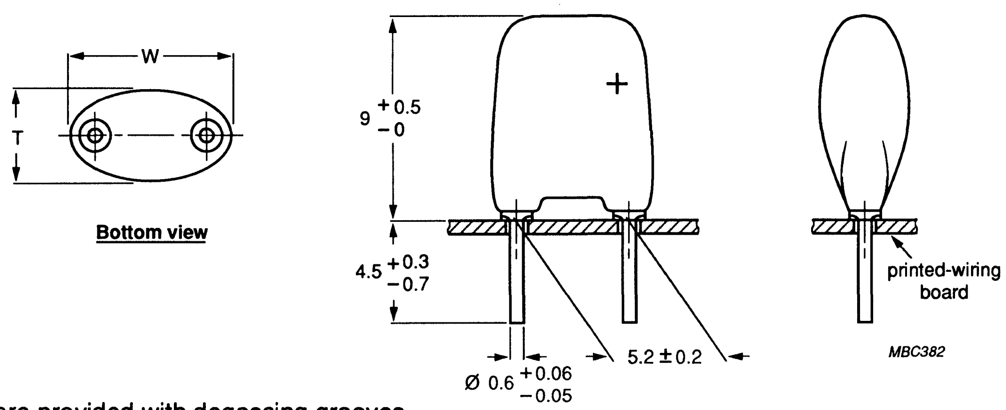
C_R (µF)	U_R (V)					
	6.3	**10**	**16**	**25**	**35**	**40**
	U_C (V)					
	6.3	**10**	**16**	**25**	**25**	**25**
0.1						9.5 x 7 x 3
0.15						9.5 x 7 x 3
0.22						9.5 x 7 x 3.5
0.33					9.5 x 7 x 3.5	9.5 x 7 x 4
0.47					9.5 x 7 x 4	9.5 x 7 x 5
0.68				9.5 x 7 x 3.5	9.5 x 7 x 4	9.5 x 7 x 5
1				9.5 x 7 x 3.5	9.5 x 7 x 5	9.5 x 8 x 5
1.5				9.5 x 7 x 3.5	9.5 x 8 x 5	9.5 x 8 x 6
2.2			9.5 x 7 x 3.5	9.5 x 7 x 4	9.5 x 8 x 6	9.5 x 8 x 6 [1)]
3.3			9.5 x 7 x 3.5	9.5 x 7 x 5	9.5 x 8 x 6 [1)]	
4.7		9.5 x 7 x 3.5	9.5 x 7 x 4	9.5 x 8 x 5		
6.8		9.5 x 7 x 3.5	9.5 x 7 x 4	9.5 x 8 x 6		
10	9.5 x 7 x 3.5	9.5 x 7 x 4	9.5 x 7 x 5	9.5 x 8 x 6 [1)]		
15		9.5 x 7 x 4	9.5 x 8 x 5			
22	9.5 x 7 x 4	9.5 x 7 x 5	9.5 x 8 x 6 [1)]			
33	9.5 x 7 x 5	9.5 x 8 x 5				
47	9.5 x 8 x 5	9.5 x 8 x 6				
68	9.5 x 8 x 6					

Note

[1)] Non CECC types.

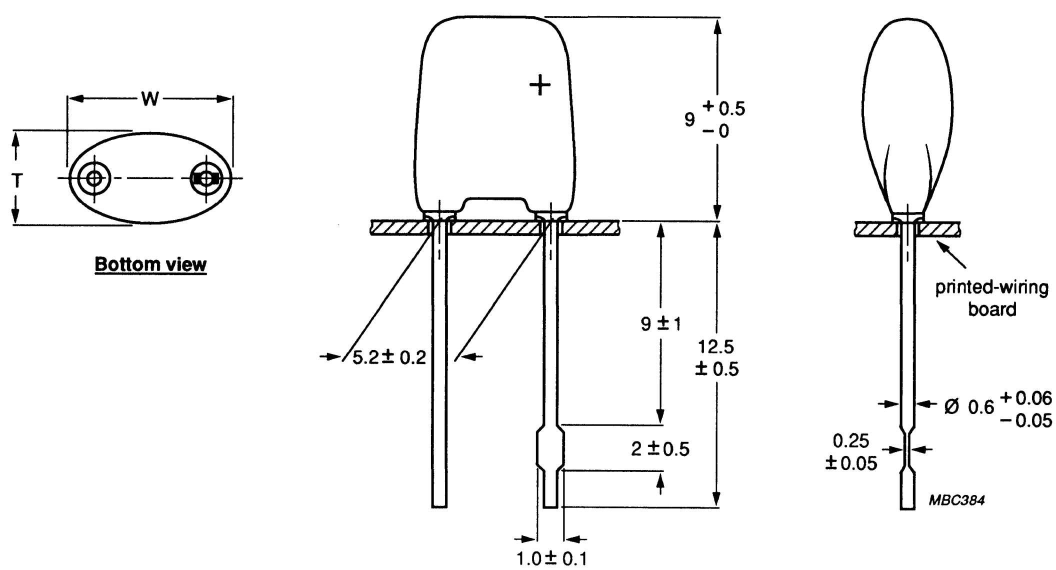
MECHANICAL DATA, AVAILABLE FORMS and PACKING QUANTITIES

Dimensions in mm.



Flanges are provided with degassing grooves.

Fig.2 **Form CB**: Short leads in boxes.



The diameter of the mounting holes in the printed-wiring board is 0.8 ±0.1 mm, except for the hole of the anode lead of Form CA capacitors: 1.3 −0.2 mm.

Flanges are provided with degassing grooves.

Fig.3 **Form CA**: Long leads with keyed polarity, in boxes.

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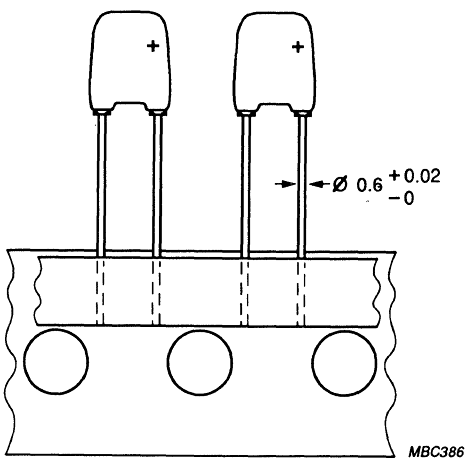
Table 2 Dimensions in mm; mass in g

CASE		APPROX. MASS	PACKING QUANTITIES			
SIZE H_{max} x W_{max} x T_{max}	CODE		FORM CA [1]	FORM CB [1]	FORM TR+	FORM TFA
9.5 x 7 x 3	10	0.22	1000	1000	2000	2000
9.5 x 7 x 3.5	20	0.25	1000	1000	2000	2000
9.5 x 7 x 4	30	0.30	1000	1000	2000	2000
9.5 x 7 x 5	40	0.35	1000	1000	1000	1000
9.5 x 8 x 5	50	0.50	1000	1000	1000	1000
9.5 x 8 x 6	60	0.60	1000	1000	1000	1000

Note

[1] In plastic bags of 200 units each.

Tape dimensions are specified in chapter "PACKING".



Form TR+: Taped on reel, positive leading.

Form TFA: Taped in ammopack.

Fig.4 Taped versions.

MARKING

The capacitors are marked (where possible) with the following information:

- Rated capacitance
- Tolerance code on rated capacitance (M = ±20%, K = ±10%)
- Rated voltage (and category voltage if applicable)
- Date code in accordance with IEC 62
- Name of manufacturer
- '+' signs to identify the anode terminal
- '-' sign to identify the cathode terminal.

Mounting

When bending, cutting or straightening the leads, ensure that the capacitor body is relieved of stress.
Bending after soldering must be avoided.

ELECTRICAL DATA

Unless otherwise specified, all electrical values in Tables 3 and 4 apply at T_{amb} = 20 to 25 °C, P = 86 to 106 kPa, RH = 45 to 75%.

C_R	= rated capacitance at 100 Hz (tolerance ±20%)
I_R	= max. RMS ripple current no necessary DC applied
I_{L5}	= max. leakage current after 5 minutes at U_R
tan δ	= max. dissipation factor at 100 Hz
ESR	= max. equivalent series resistance at 100 Hz
Z	= max. impedance at 100 kHz.

Table 3 Electrical data for 128 series

U_C (V)	U_R (V)	C_R 100 Hz (μF)	MAXIMUM CASE SIZE H x W x T (mm)	I_R 100 Hz 125 °C (mA)	I_R 10 kHz 85 °C (mA)	I_R 100 kHz 40 °C (mA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 100 kHz (Ω)
6.3	6.3	10	9.5 x 7 x 3.5	9	156	211	2	0.10	20	3.0
		22	9.5 x 7 x 4	20	234	317	4	0.10	9	1.0
		33	9.5 x 7 x 5	30	293	396	5	0.10	6.1	0.7
		47	9.5 x 8 x 5	42	371	502	7	0.10	4.8	0.5
		68	9.5 x 8 x 6	61	449	607	11	0.10	3.0	0.5
10	10	4.7	9.5 x 7 x 3.5	7	117	158	2	0.10	43	3.0
		6.8	9.5 x 7 x 3.5	10	137	185	2	0.10	30	3.0
		10	9.5 x 7 x 4	14	156	211	3	0.10	20	1.5
		15	9.5 x 7 x 4	21	195	264	4	0.10	14	1.0
		22	9.5 x 7 x 5	31	234	317	6	0.10	9	0.7
		33	9.5 x 8 x 5	47	312	422	8	0.10	6.1	0.5
		47	9.5 x 8 x 6	70	312	422	12	0.10	4.3	0.5
16	16	2.2	9.5 x 7 x 3.5	5	98	132	2	0.10	91	5.0
		3.3	9.5 x 7 x 3.5	8	117	158	2	0.10	61	5.0
		4.7	9.5 x 7 x 4	11	137	185	2	0.10	43	2.0
		6.8	9.5 x 7 x 4	16	156	211	3	0.10	30	1.5
		10	9.5 x 7 x 5	23	195	264	4	0.10	20	1.0
		15	9.5 x 8 x 5	34	254	343	6	0.10	14	0.7
		22	9.5 x 8 x 6	50	254	343	9	0.10	9	0.7

ORDERING INFORMATION

Ordering example

Electrolytic capacitors 2222 128 . . . . .
10 µF/16 V, ±20%
Form CB
Catalogue number: 2222 128 55109.

Table 4 Ordering information for 128 series

U_C (V)	U_R (V)	C_R 100 Hz (µF)	MAXIMUM CASE SIZE H x W x T (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . [1]			
					FORM CB	FORM CA	FORM TR+ on reel	FORM TFA in ammopack
6.3	6.3	10	9.5 x 7 x 3.5	20	128 53109	128 73109	128 23109	128 33109
		22	9.5 x 7 x 4	30	128 53229	128 73229	128 23229	128 33229
		33	9.5 x 7 x 5	40	128 53339	128 73339	128 23339	128 33339
		47	9.5 x 8 x 5	50	128 53479	128 73479	128 23479	128 33479
		68	9.5 x 8 x 6	60	128 53689	128 73689	128 23689	128 33689
10	10	4.7	9.5 x 7 x 3.5	20	128 54478	128 74478	128 24478	128 34478
		6.8	9.5 x 7 x 3.5	20	128 54688	128 74688	128 24688	128 34688
		10	9.5 x 7 x 4	30	128 54109	128 74109	128 24109	128 34109
		15	9.5 x 7 x 4	30	128 54159	128 74159	128 24159	128 34159
		22	9.5 x 7 x 5	40	128 54229	128 74229	128 24229	128 34229
		33	9.5 x 8 x 5	50	128 54339	128 74339	128 24339	128 34339
		47	9.5 x 8 x 6	60	128 54479	128 74479	128 24479	128 34479
16	16	2.2	9.5 x 7 x 3.5	20	128 55228	128 75228	128 25228	128 35228
		3.3	9.5 x 7 x 3.5	20	128 55338	128 75338	128 25338	128 35338
		4.7	9.5 x 7 x 4	30	128 55478	128 75478	128 25478	128 35478
		6.8	9.5 x 7 x 4	30	128 55688	128 75688	128 25688	128 35688
		10	9.5 x 7 x 5	40	128 55109	128 75109	128 25109	128 35109
		15	9.5 x 8 x 5	50	128 55159	128 75159	128 25159	128 35159
		22	9.5 x 8 x 6	60	128 55229	128 75229	128 25229	128 35229

U_C (V)	U_R (V)	C_R 100 Hz (μF)	MAXIMUM CASE SIZE H x W x T (mm)	I_R 100 Hz 125 °C (mA)	I_R 10 kHz 85 °C (mA)	I_R 100 kHz 40 °C (mA)	I_{L5} 5 min (μA)	Tan δ 100 Hz	ESR 100 Hz (Ω)	Z 100 kHz (Ω)
25	25	0.68	9.5 x 7 x 3.5	2	55	74	2	0.10	295	20
		1	9.5 x 7 x 3.5	4	62	85	2	0.10	200	15
		1.5	9.5 x 7 x 3.5	5	78	106	2	0.10	135	15
		2.2	9.5 x 7 x 4	8	98	132	2	0.10	91	10
		3.3	9.5 x 7 x 5	12	117	158	2	0.10	61	7
		4.7	9.5 x 8 x 5	17	137	185	3	0.10	43	5
		6.8	9.5 x 8 x 6	24	176	238	4	0.10	30	3
		10	9.5 x 8 x 6	35	176	238	6	0.10	20	2
25	35	0.33	9.5 x 7 x 3.5	1	39	53	2	0.10	610	30
		0.47	9.5 x 7 x 4	2	47	63	2	0.10	430	30
		0.68	9.5 x 7 x 4	2	55	74	2	0.10	295	20
		1	9.5 x 7 x 5	4	62	85	2	0.10	200	15
		1.5	9.5 x 8 x 5	5	78	106	2	0.10	135	10
		2.2	9.5 x 8 x 6	8	98	132	2	0.10	91	5
		3.3	9.5 x 8 x 6	12	117	158	3	0.10	61	5
25	40	0.1	9.5 x 7 x 3	0.4	20	26	2	0.10	1990	70
		0.15	9.5 x 7 x 3	0.5	23	32	2	0.10	1330	50
		0.22	9.5 x 7 x 3.5	0.8	31	42	2	0.10	910	30
		0.33	9.5 x 7 x 4	1	39	53	2	0.10	610	30
		0.47	9.5 x 7 x 5	2	47	63	2	0.10	430	20
		0.68	9.5 x 7 x 5	2	55	74	2	0.10	295	15
		1	9.5 x 8 x 5	4	62	85	2	0.10	200	10
		1.5	9.5 x 8 x 6	5	78	106	2	0.10	135	7
		2.2	9.5 x 8 x 6	8	98	132	2	0.10	91	5

U_C (V)	U_R (V)	C_R 100 Hz (μF)	MAXIMUM CASE SIZE H x W x T (mm)	CASE CODE	CATALOGUE NUMBER 2222 . . . . [1] FORM CB	FORM CA	FORM TR+ on reel	FORM TFA in ammopack
25	25	0.68	9.5 x 7 x 3.5	20	128 56687	128 76687	128 26687	128 36687
		1	9.5 x 7 x 3.5	20	128 56108	128 76108	128 26108	128 36108
		1.5	9.5 x 7 x 3.5	20	128 56158	128 76158	128 26158	128 36158
		2.2	9.5 x 7 x 4	30	128 56228	128 76228	128 26228	128 36228
		3.3	9.5 x 7 x 5	40	128 56338	128 76338	128 26338	128 36338
		4.7	9.5 x 8 x 5	50	128 56478	128 76478	128 26478	128 36478
		6.8	9.5 x 8 x 6	60	128 56688	128 76688	128 26688	128 36688
		10	9.5 x 8 x 6	60	128 56109	128 76109	128 26109	128 36109
25	35	0.33	9.5 x 7 x 3.5	20	128 50337	128 70337	128 20337	128 30337
		0.47	9.5 x 7 x 4	30	128 50477	128 70477	128 20477	128 30477
		0.68	9.5 x 7 x 4	30	128 50687	128 70687	128 20687	128 30687
		1	9.5 x 7 x 5	40	128 50108	128 70108	128 20108	128 30108
		1.5	9.5 x 8 x 5	50	128 50158	128 70158	128 20158	128 30158
		2.2	9.5 x 8 x 6	60	128 50228	128 70228	128 20228	128 30228
		3.3	9.5 x 8 x 6	60	128 50338	128 70338	128 20338	128 30338
25	40	0.1	9.5 x 7 x 3	10	128 57107	128 77107	128 27107	128 37107
		0.15	9.5 x 7 x 3	10	128 57157	128 77157	128 27157	128 37157
		0.22	9.5 x 7 x 3.5	20	128 57227	128 77227	128 27227	128 37227
		0.33	9.5 x 7 x 4	30	128 57337	128 77337	128 27337	128 37337
		0.47	9.5 x 7 x 5	40	128 57477	128 77477	128 27477	128 37477
		0.68	9.5 x 7 x 5	40	128 57687	128 77687	128 27687	128 37687
		1	9.5 x 8 x 5	50	128 57108	128 77108	128 27108	128 37108
		1.5	9.5 x 8 x 6	60	128 57158	128 77158	128 27158	128 37158
		2.2	9.5 x 8 x 6	60	128 57228	128 77228	128 27228	128 37228

Note

[1] The 8th digit of the catalogue number represents the tolerance, as follows:

TOLERANCE	FORM CB	FORM CA	FORM TR+	FORM TFA
±20% : 2222	128 5....	128 7....	128 2....	128 3....
±10% : 2222	128 4....	128 6....	128 1....	to special order

Voltage

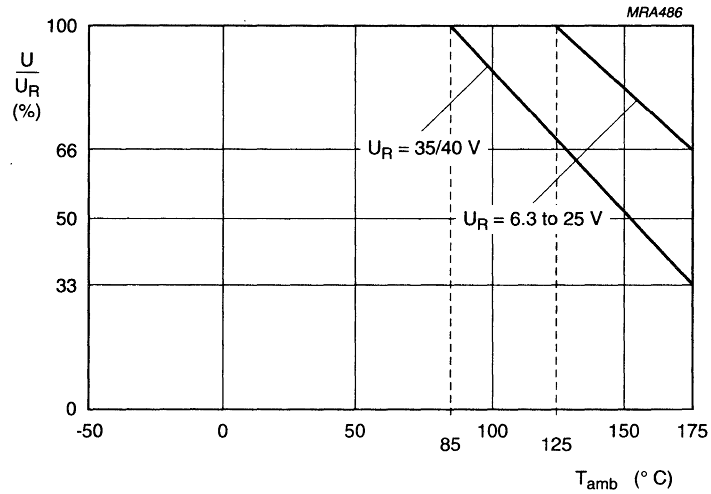


Fig.5 Maximum permissible voltage up to 175 °C.

Surge voltage for short periods	$U_s \leq 1.15 \bullet U_R$	
Reverse voltage	$U_{rev} < 0.3 \bullet U_R$	
Max. peak AC voltage, reverse voltage applied	≤ 2 V	
Max. peak AC voltage, without reverse voltage applied		
	$T_{amb} \leq 85$ °C	85 °C $< T_{amb} \leq 125$ °C
at f ≤ 0.1 Hz	0.30 x U_R	0.15 x U_R
at 0.1 Hz < f ≤ 1 Hz	0.45 x U_R	0.22 x U_R
at 1 Hz < f ≤ 10 Hz	0.60 x U_R	0.30 x U_R
at 10 Hz < f ≤ 50 Hz	0.65 x U_R	0.32 x U_R
at f > 50 Hz	0.80 x U_R	0.40 x U_R

Ripple current (I_R)

Applying the max. RMS ripple current given in Table 3 will cause a device temperature of 138 °C. The 100 kHz values in Table 3 for other temperatures are to be calculated with the following I_R multipliers:

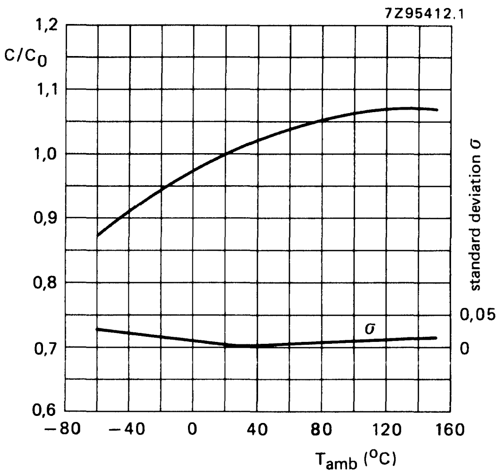
T_{amb}	25 °C	40 °C	65 °C	85 °C	105 °C	125 °C
I_R multiplier	1.1	1.0	0.88	0.75	0.59	0.37

Max. power dissipation

case sizes 9.5 x 7 x 3 to 9.5 x 7 x 5: P_{125} = 88 mW

case size 9.5 x 8 x 5 and 9.5 x 8 x 6: P_{125} = 104 mW.

Capacitance (C)



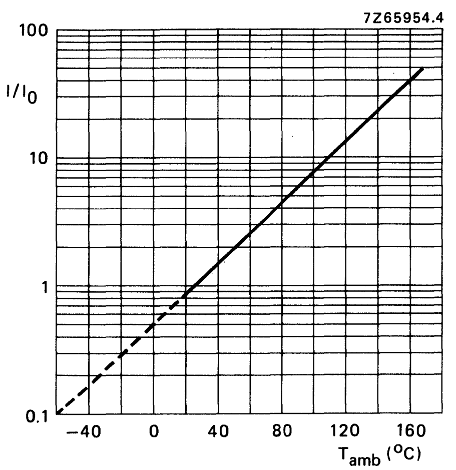
C_0 = capacitance at 25 °C and 100 Hz.

Fig.6 Typical multiplier of capacitance (C/C_0) as a function of ambient temperature.

Typical parameter change after endurance test at T_{amb} = 125 °C.

Fig.7 Change of capacitance after endurance test.

Leakage current



I_0 = leakage current during continuous operation at U_R and T_{amb} = 25 °C.

Fig.8 Typical multiplier of leakage current (I/I_0) as a function of ambient temperature.

Maximum leakage current after 5 minutes at U_R and T_{amb} = 25 °C	$I_{L5} \leq 0.025\ C_R \times U_R$ or 2 µA, whichever is greater (see Table 3)

Typical leakage current 15 s at U_R and T_{amb} = 25 °C

6.3V to 16 V versions	approx. 0.2 x value stated in Table 3
25V to 40 V versions	approx. 0.1 x value stated in Table 3

Typical parameter change after endurance test at T_{amb} = 125 °C.

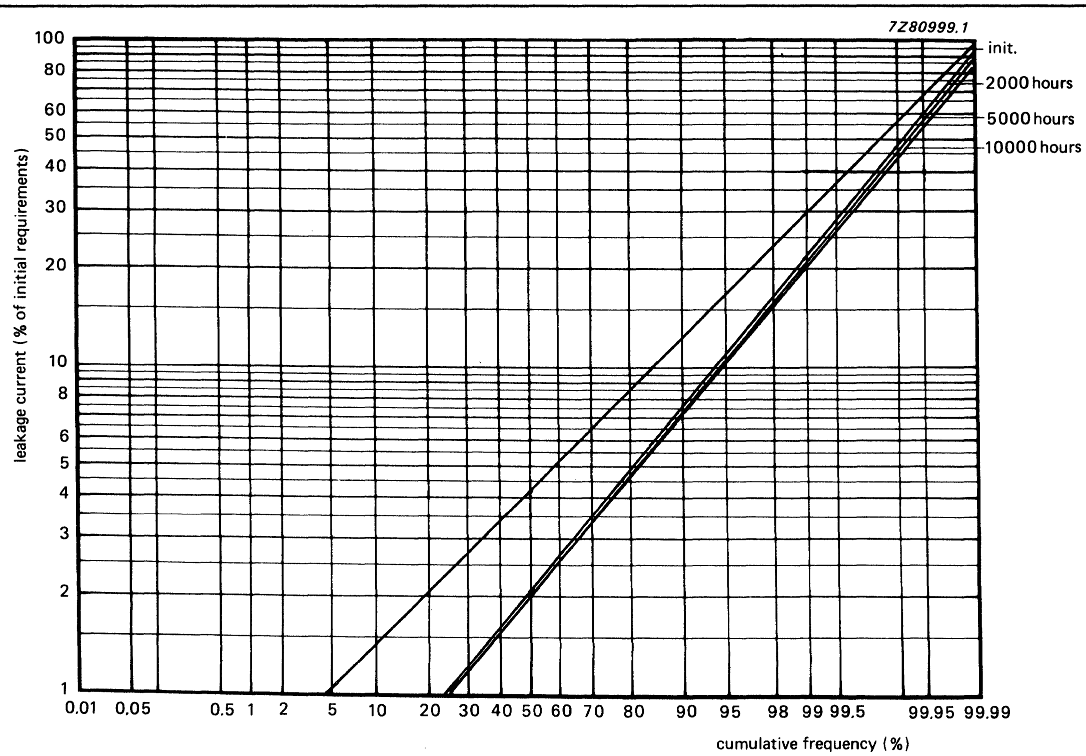


Fig.9 Leakage current after endurance test.

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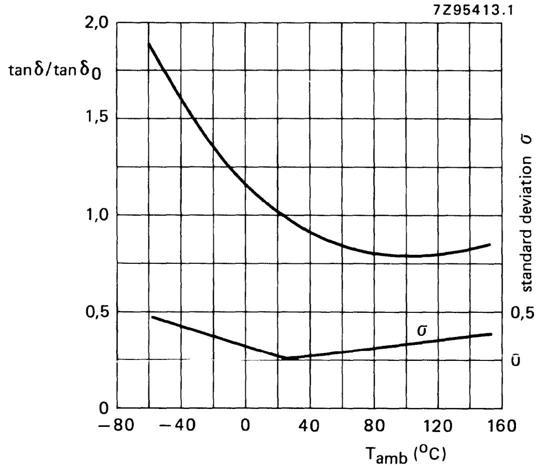
Dissipation factor (tan δ)



tan δ_0 = dissipation factor at T_{amb} = 25 °C and 100 Hz.

Fig.10 Typical multiplier of dissipation factor (tan δ/tan δ_0) as a function of temperature.

Typical parameter change after endurance test at T_{amb} = 125 °C.

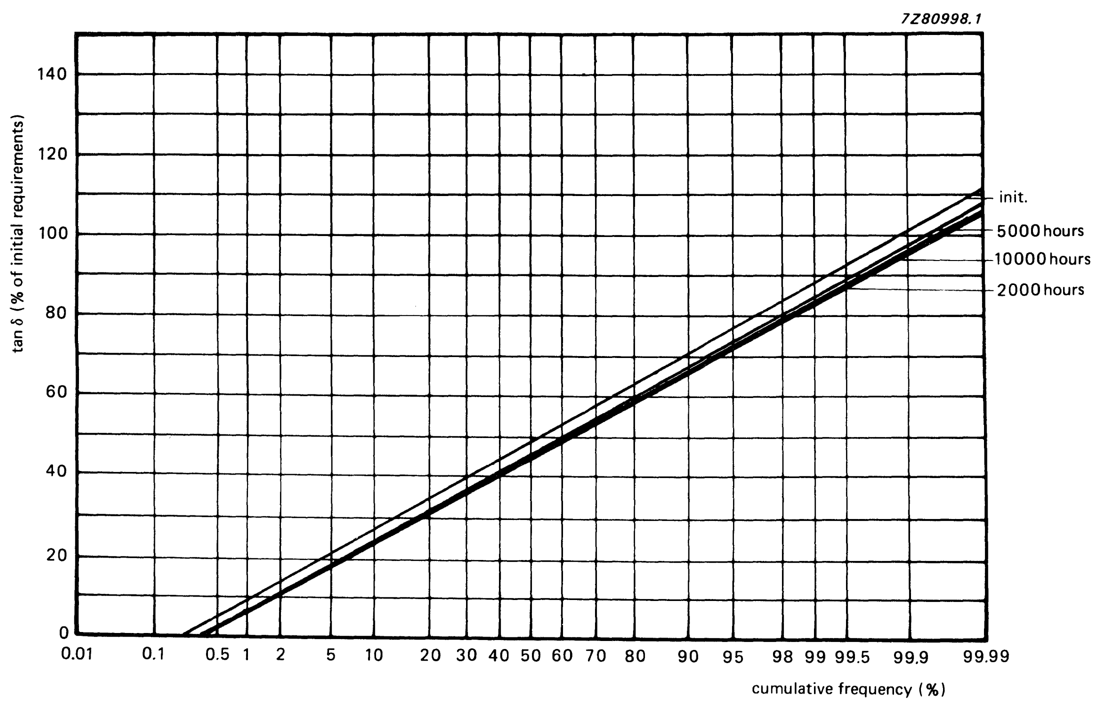


Fig.11 Tan δ after endurance test.

Equivalent series resistance (ESR)

Curve 1 : 0.1 μF, 40 V
Curve 2 : 1.5 μF, 40 V
Curve 3 : 3.3 μF, 25 V
Curve 4 : 10 μF, 6.3 V
Curve 5 : 22 μF, 10 V

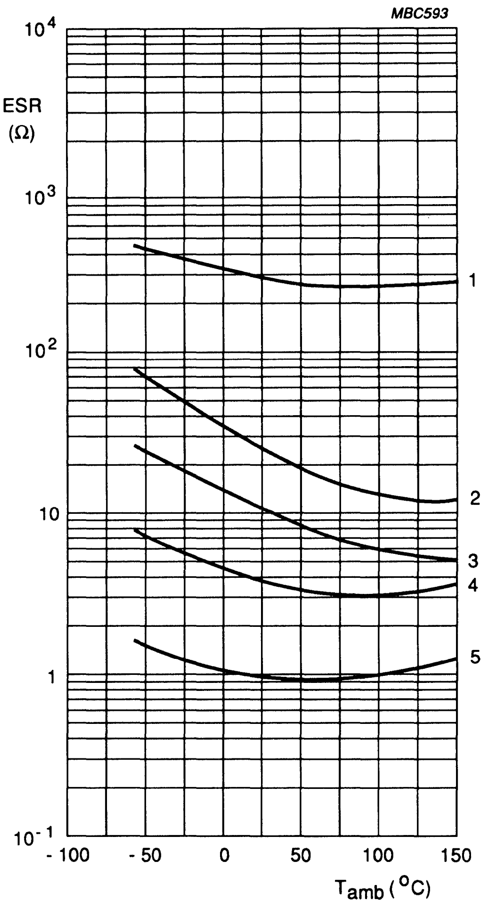


Fig.12 Typical ESR as a function of temperature at 100 Hz.

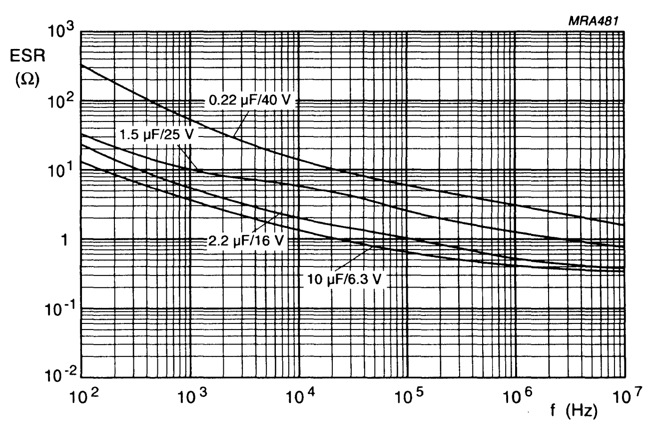


Fig.13 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 7 x 3.5 mm.

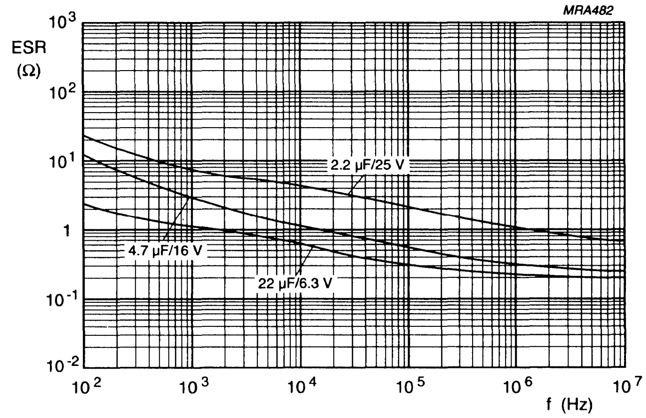


Fig.14 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 7 x 4 mm.

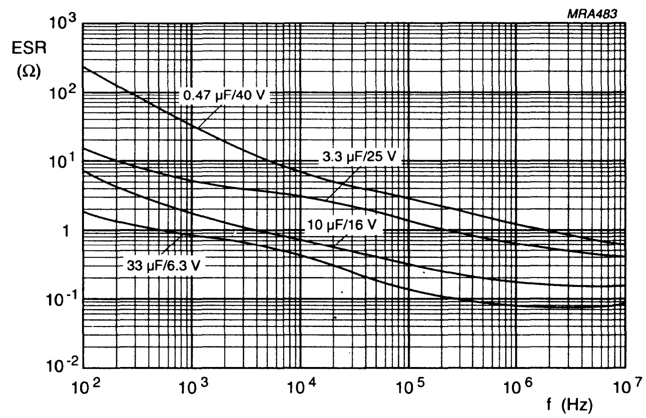


Fig.15 Typical ESR as a function of frequency at T_{amb} = 25 °C; case sizes 9.5 x 7 x 5 mm.

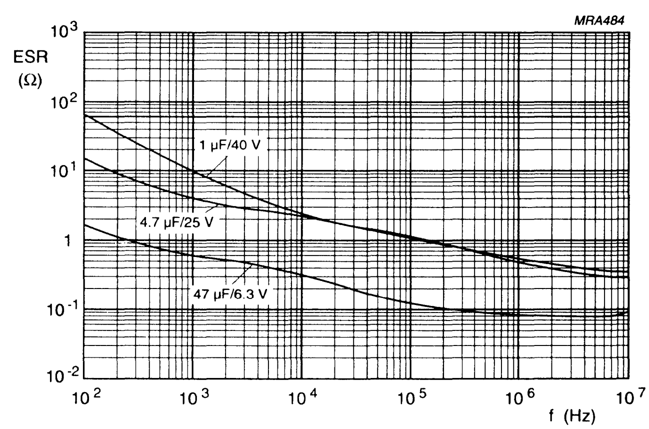


Fig.16 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 8 x 5 mm.

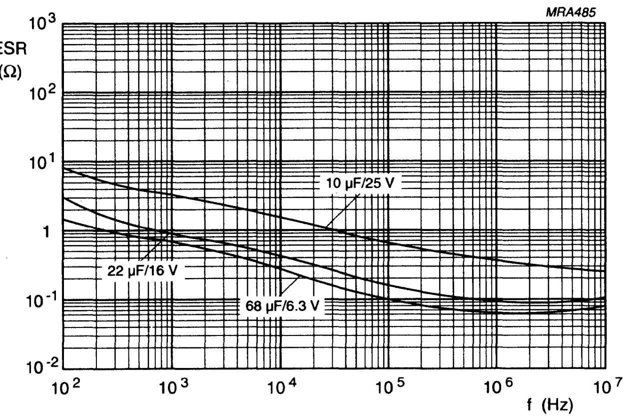
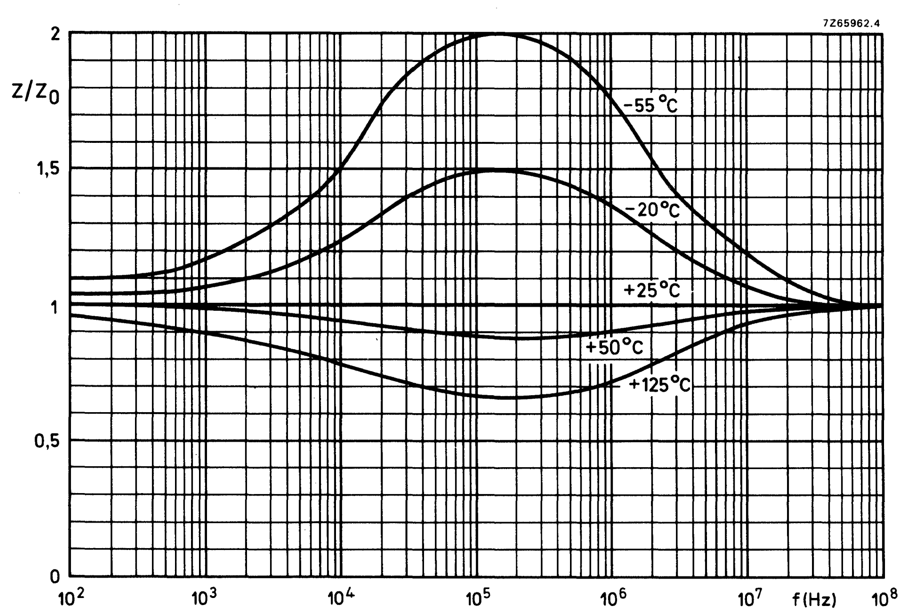


Fig.17 Typical ESR as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 8 x 6 mm.

Equivalent series inductance (ESL), f = 10 MHz

Typical ESL for; case sizes 9.5 x 7 x 3 to 9.5 x 7 x 5	9 to 14 nH
Typical ESL for; case sizes 9.5 x 8 x 5 and 9.5 x 8 x 6	11 to 16 nH
Maximum ESL for all; case sizes	20 nH

Impedance (Z)



Z_0 = initial impedance value at T_{amb} = 25 °C.

Fig.18 Typical multiplier of impedance (Z/Z_0) as a function of frequency at different temperatures.

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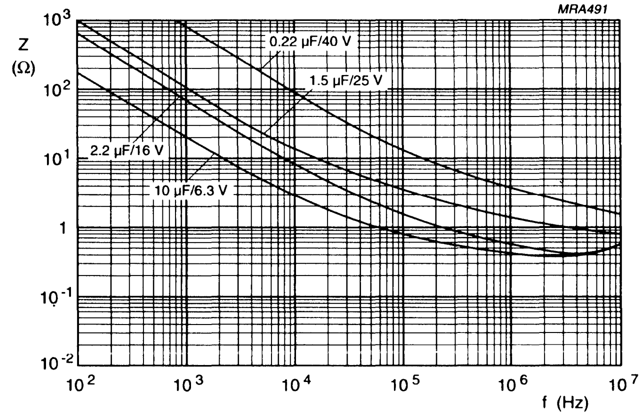


Fig.19 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 7 x 3.5 mm.

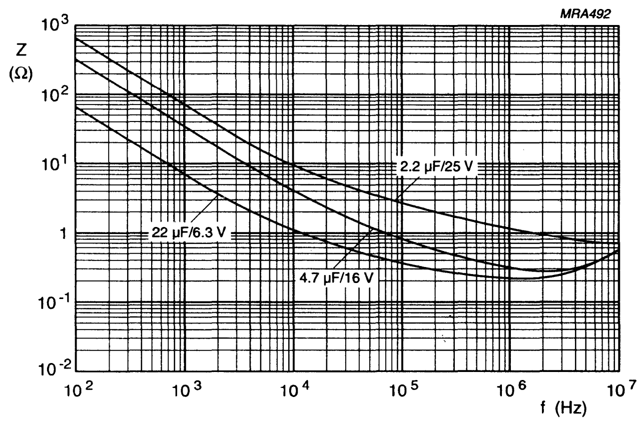


Fig.20 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 7 x 4 mm.

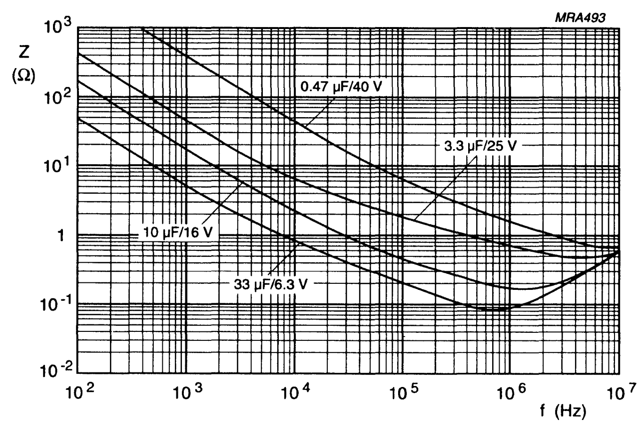


Fig.21 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 7 x 5 mm.

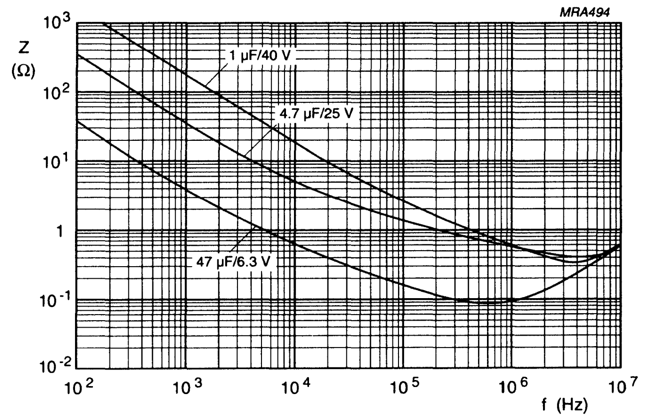


Fig.22 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 8 x 5 mm.

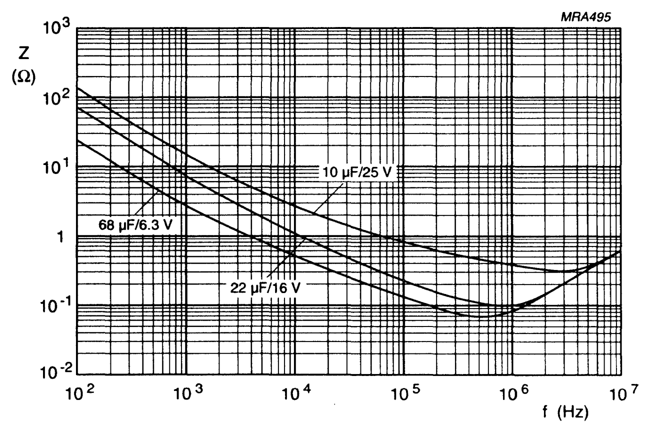


Fig.23 Typical impedance as a function of frequency at T_{amb} = 25 °C; case size 9.5 x 8 x 6 mm.

SPECIFIC TESTS and REQUIREMENTS

General tests and requirements are specified in chapter "Tests and Requirements".

Table 5

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Endurance	IEC 384-4-2/ CECC 30 302 group C3, 4.13	T_{amb} = 125 °C U_R = 6.3 to 25 V with U_R applied U_R = 35 and 40 V with U_C applied 10 000 hours	$\Delta C/C$ ≤±10% tan δ ≤1.2 x spec. limit Z ≤1.2 x spec. limit I_{L5} ≤spec. limit
Useful life	CECC 30 302 amendment 2642 sub clause 1.8.1	T_{amb} = 125 °C, I_R applied and U_R = 6.3 to 25 V with U_R applied U_R = 35 and 40 V with U_C applied 20 000 hours	$\Delta C/C$ ≤15% tan δ ≤1.5 x spec. limit Z ≤1.5 x spec. limit I_{L5} ≤spec. limit no short or open circuit no visible damage total failure percentage <1%
Shelf life (storage at high temp.)	IEC 384-4-2/ CECC 30 302 group C 5a, 4.17	T_{amb} = 125 °C, no voltage applied 500 hours	$\Delta C/C$ ≤±10% tan δ ≤1.2 x spec. limit I_{L5} ≤1 x spec. limit
Charge and discharge	IEC 384-4-2 sub clause 9.21	10^6 cycles without series resistance 0.5 s to U_R 0.5 s to ground	$\Delta C/C$ ≤5% no short or open circuit no visible damage
Solvent resistance test	IEC 68-2-45, IEC 653 test XA	sequence: - 30 s vapour phase - 5 minutes ultrasonic immersion at ambient temperature - 30 s vapour phase Solvents: - deionized water (50 ±5 °C); - calgonite solution (20 g/l, 70 ±5 °C); - 1.1.1.-trichloro-ethane; - mixtures of 1.1.2.-trichloro-1.2.2.-trifluoro-ethane (fluorocarbon 113) and the following solvents in the respective mass percentage ratios of these solvents to fluorocarbon; * ARKLONE K; 75% w/w F113 and 25% w/w isopropanol * FREON TE; 95.5% w/w F113 and 4.5% w/w ethanol * FREON TMS; 94% w/w F113, 5.7% w/w methanol and 0.3% w/w nitro-methane *ARKLONE F; 95.6% w/w F113, 4.0% w/w ethylalcohol, 0.07% w/w stabilizer and 0.3% w/w special additives * ARKLONE A-M; 94.15% w/w F113, 3.7% w/w ethylalcohol, 2.1% w/w methylacetate and 0.05% w/w stabilizer	visual appearance not affected

TEST		PROCEDURE (quick reference)	REQUIREMENTS
Name of test	**Reference**		
Extended vibration test	IEC 68-2-6 test Fc	10 to 2 000 Hz 1.5 mm or 20 g 1 octave/minute 3 directions 1 sweep per direction no voltage applied	no intermittent contacts; no breakdown; no open circuiting; no mechanical damage; $\Delta C/C \leq 5\%$ $\tan\delta \leq 1.2$ x spec. limit $Z \leq 1.2$ x spec. limit $I_{L5} \leq 1.5$ x spec. limit
Shock test	IEC 68-2-27 test Ea	half-sine or saw tooth pulse shape 50 g, 11 ms, 3 successive shocks in each direction of 3 mutually perpendicular axes, no voltage applied	no intermittent contacts; no breakdown; no open circuiting; no mechanical damage; $\Delta C/C \leq 5\%$ $\tan\delta \leq 1.2$ x spec. limit $Z \leq 1.2$ x spec. limit $I_{L5} \leq 1.5$ x spec. limit
Passive flammability test	IEC 695-2-2	capacitor mounted to a vertical printed-wiring board, one flame on capacitor body, T_{amb} = 20 to 25 °C, test duration = 20 s.	after removing the test flame from the capacitor, the capacitor must not continue to burn for more than 15 s; no burning particles must drop from the sample

Notes

1. ARKLONE is a trade mark of I.C.I.
2. FREON is a trade mark of Dupont de Nemours.

CAPACITOR PRINCIPLES

The essential property of a capacitor is to store electrical charge. The amount of electrical charge (Q) in the capacitor (C) is proportional to the applied voltage (U). The relationship of these parameters is:

$$Q = C \cdot U$$

where

- Q = charge in coulombs (C)
- C = capacitance in farads (F)
- U = voltage in volts (V).

The value of capacitance is directly proportional to the (anode) surface area and inversely proportional to the thickness of the dieletric layer, thus:

$$C = \varepsilon_r \cdot \varepsilon_o \cdot \frac{A}{d}$$

where

- ε_o = absolute permittivity (8.85×10^{-12} F/m)
- ε_r = relative dielectric constant (dimensionless)
- A = surface area (m^2)
- d = thickness of the dielectric (oxide layer in electrolytic capacitors) in m

Energy content of a capacitor:

The energy content of a capacitor is given by:

$$P = \frac{1}{2}\, C \cdot U^2$$

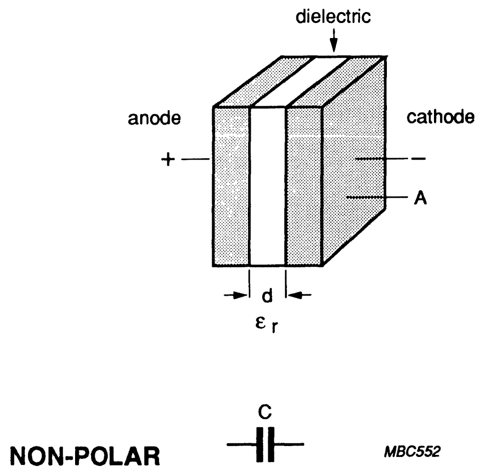
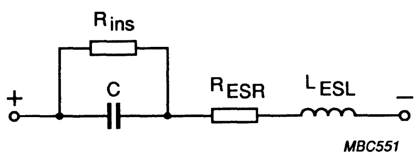


Fig.1 Equivalent circuit of an ideal capacitor.



POLAR

Anode electrode:
valve effect metal; aluminium or tantalum.
Dielectric:
Al_2O_3 or Ta_2O_5.
Cathode electrode, solid or non-solid electrolyte depending on technology
non-solid: wet electrolyte spacer and aluminium foil
solid: solid electrolyte (manganese dioxide), graphite and silver epoxy.

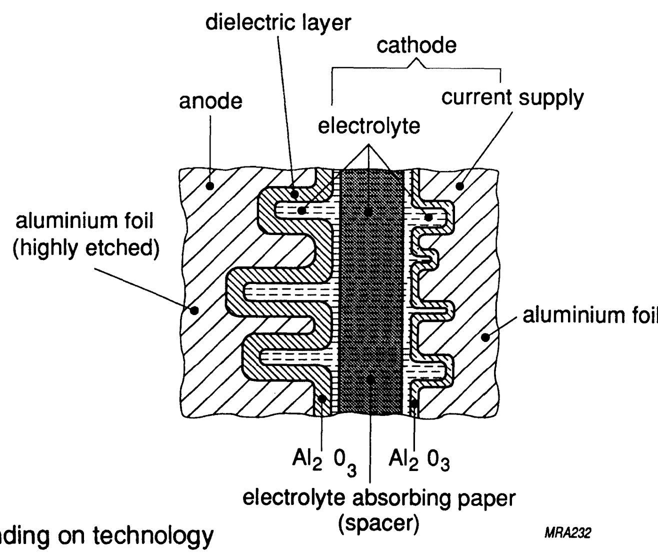


Fig.2 Equivalent circuit of an electrolytic capacitor.

ELECTRICAL BEHAVIOUR

CHARACTERISTICS OF ELECTROLYTIC CAPACITORS VARY WITH TEMPERATURE, FREQUENCY, TIME AND APPLIED VOLTAGE.

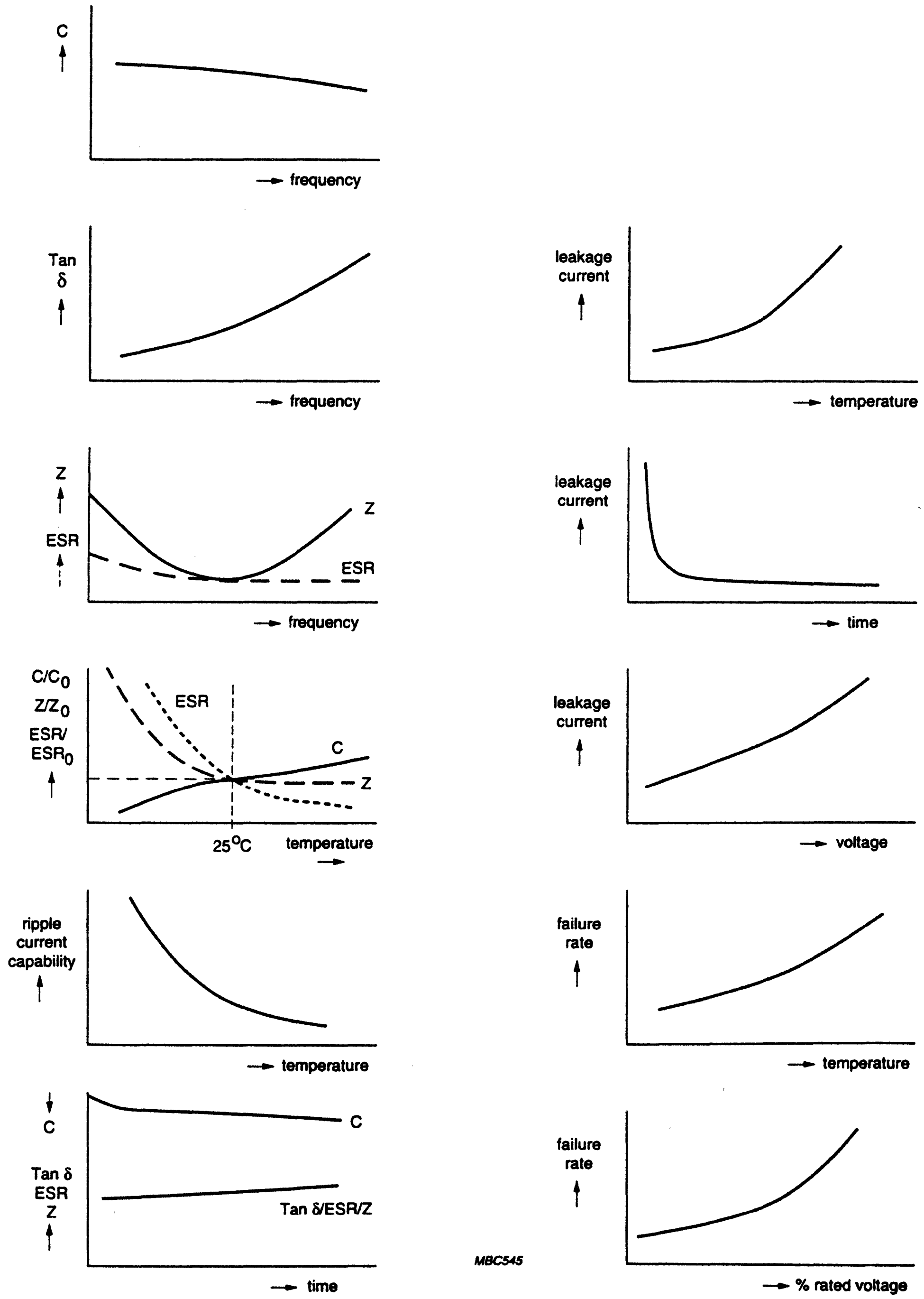


Fig.3 Typical variation of electrical parameters as a function of frequency, ambient temperature, voltage and time.

CONSTRUCTION

Examples

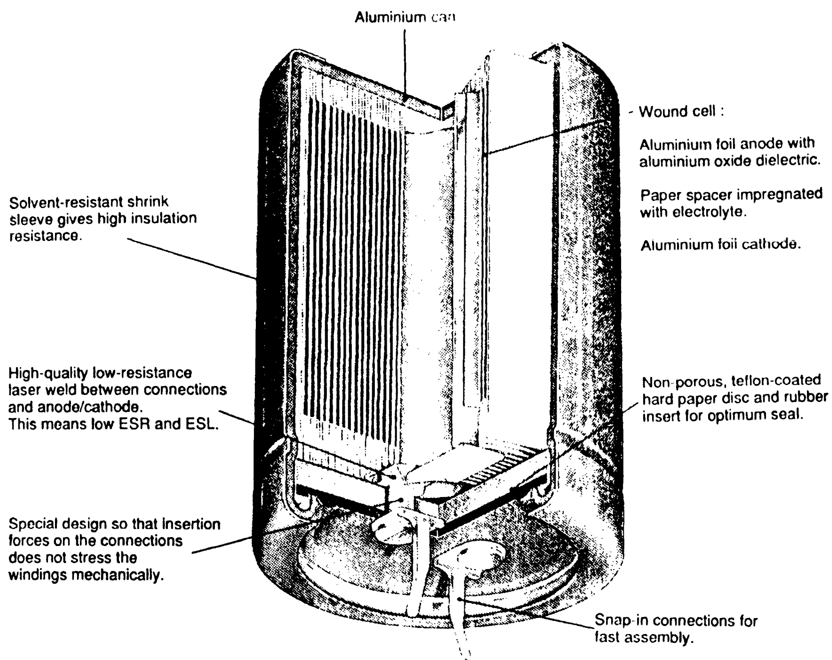


Fig.4 Power non-solid Aluminium, snap-in.

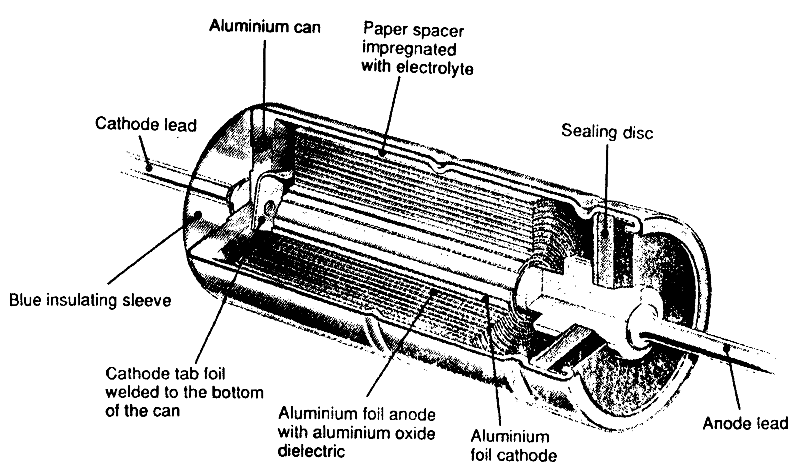


Fig.5 Non-solid Aluminium, axial.

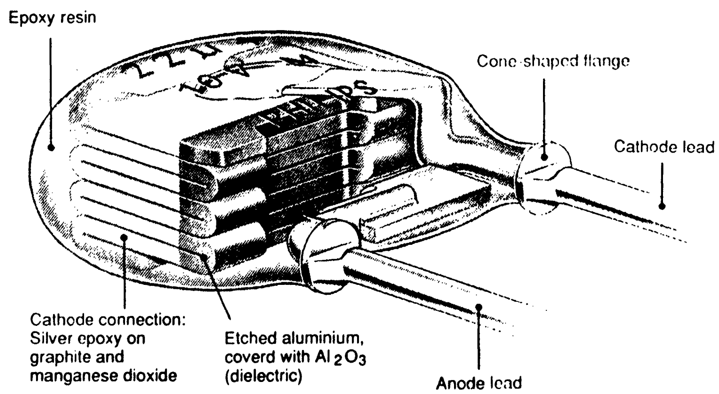


Fig.6 Solid Aluminium (SAL), radial.

DEFINITIONS OF THE ELECTRICAL PARAMETERS

CAPACITANCE

AC Capacitance of an electrolytic capacitor

The capacitance of an equivalent circuit, having capacitance and resistance in series, measured with alternating current approximately sinusoidal waveform at a specified frequency, refer to Fig. 8.
Standard measuring frequencies for electrolytic capacitors are 100 or 120 Hz.

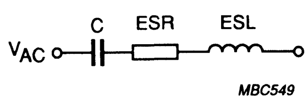


Fig.8 AC equivalent circuit of an electrolytic capacitor.

DC Capacitance of an electrolytic capacitor (for timing circuits)

DC capacitance is given by the amount of charge which is stored in the capacitor at the rated voltage (U_R). DC capacitance is measured by a single discharge of the capacitor under defined conditions. Measuring procedures are described in DIN 41328, sheet.4.
At any given time, the DC capacitance is higher than the AC capacitance.

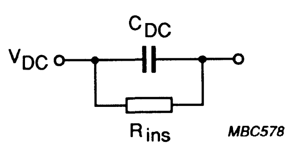


Fig.9 DC equivalent circuit of an electrolytic capacitor.

Rated capacitance (C_R)

The capacitance value for which the capacitor has been designed and which is usually indicated upon it.
Preferred values of rated capacitance and their decimal multiples are chosen from the E3 or E6 series of IEC Publication 63.

Tolerance on rated capacitance

Preferred values of tolerances on rated capacitance are:

−20/+20%, −10/+50%, −10/+30 and −10/+10%

VOLTAGE

Rated voltage (U_R)

The maximum direct voltage, or peak value of pulse voltage which may be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature.

Category voltage (U_C)

The maximum voltage which may be applied continuously to a capacitor at its upper category temperature.

Temperature derated voltage

The temperature derated voltage is the maximum voltage that may be applied continuously to a capacitor, for any temperature between the rated temperature and the upper category temperature,

Ripple voltage (U_{Rpl})

An alternating voltage may be applied, provided that the peak voltage resulting from the alternating voltage, when superimposed on the direct voltage, does not exceed the value of rated direct voltage and that the ripple current and the permissible reverse voltage are not exceeded.

Reverse voltage (U_{rev})

The maximum voltage applied in the reverse polarity direction to the capacitor terminations.

Surge voltage (U_s)

The maximum instantaneous voltage which may be applied to the terminations of the capacitor for a specified time at any temperature within the category temperature range.

TEMPERATURE

Category temperature range

The range of ambient temperatures for which the capacitor has been designed to operate continuously: this is defined by the temperature limits of the appropriate category

Rated temperature

The maximum ambient temperature at which the rated voltage may be continuously applied.

Minimum storage temperature

The minimum permissible ambient temperature which the capacitor shall withstand in the non-operating condition, without damage.

RESISTANCE/REACTANCE

Equivalent series resistance (ESR)

The ESR of an equivalent circuit having capacitance and resistance in series measured with alternating current approximately sinusoidal waveform at a specified frequency, see Fig.8.

Equivalent series inductance (ESL)

The ESL of an equivalent circuit having capacitance, resistance and inductance in series measured with alternating current approximately sinusoidal waveform at a specified frequency, see Fig.8.

Dissipation factor, (tangent of loss angle; Tanδ)

The power loss of the capacitor divided by the reactive power of the capacitor at a sinusoidal voltage of specified frequency: $\tan\delta = ESR \cdot 2\pi fC$.

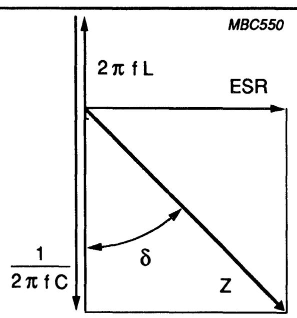


Fig.10 Vector diagram showing the AC parameters of a capacitor.

Impedance (Z)

The impedance (Z) of an electrolytic capacitor is given by capacitance, ESR and ESL according to the following equation (see Fig.10):

$$Z = \sqrt{ESR^2 + \left(2\pi f ESL - \frac{1}{2\pi f C}\right)^2}$$

CURRENT

Leakage current (I_L)

Leakage current flows through a capacitor when a DC voltage is applied in correct polarity. It is dependent on voltage, temperature and time.

Leakage current for acceptance test (I_{L5})

In accordance with international standards (IEC 384-4, CECC 30 300) the leakage current **after 5 minutes** (I_{L5}) application of rated voltage at 20 °C is considered as an acceptance requirement.
The leakage current requirements for the majority of Philips electrolytic capacitors, are lower than specified in IEC 384-4 or CECC 30 300.
If, for example, after prolonged storage and/or storage at excessive temperature (>40 °C), the leakage current at the first measurement does not meet requirements, pre-conditioning in accordance with CECC 30 300 sub clause 4.1 shall be carried out.

Leakage current at delivery (I_{L1} or I_{L2})

In addition to I_{L5}, the leakage current **after 1 minute** application of rated voltage (I_{L1}) is specified in most of the detail specifications.
For some series this value is specified **after 2 minutes** (I_{L2}).

Operational leakage current (I_{OP})

After continuous operation (1 hour or longer) the leakage current will normally decrease to less than 20% of the 5 minute value (I_{L5}).

The operational leakage current depends on applied voltage and ambient temperature (see Tables 1 and 2).

Leakage current after storage with no voltage applied (shelf life)

If non-solid electrolytic capacitors are stored above room temperature for long periods of time, the oxide layer may react with the electrolyte, causing increased leakage current when switched on for the first time after storage.

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Table 1 Typical multiplier of operational leakage current as a function of applied voltage.

U/U_R	<0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
I_L/I_{OP}	0.1	0.15	0.2	0.3	0.4	0.5	0.65	0.8	1

Table 2 Typical multiplier of operational leakage current as a function of ambient temperature (as far as allowed for the corresponding series).

T_{amb} (°C)	−55	−40	−25	0	20	45	65	85	105	125
I_L/I_{OP}	<0.5	0.5	0.6	0.8	1	1.5	2.5	4	7	10

No pre-condition will be necessary for Philips electrolytic capacitors, when stored at room temperature for the following periods of time:

2-3 years for non-solid 85 °C types
4 years for non-solid 105 °C types
10 years for non-solid 125 °C types
20 years for solid types.

After these periods, the leakage current for acceptance test shall not exceed twice the specified I_{L5} requirement.

Prior to insertion, the storage time shall not exceed 2-3 years for all types to ensure good solderability and quality of taping.

Ripple current (I_R)

Any pulsating voltage (or ripple voltage superimposed on DC bias) across a capacitor results in an alternating current through the capacitor.
Because of ohmic and dielectric losses in the capacitor, this alternating current produces an increase of temperature in the capacitor cell.
The heat generation depends on frequency and wave form of the alternating current.
The maximum RMS value of this alternating current, which is permitted to pass through the capacitor during its entire specified useful life (at defined frequency and defined ambient temperature), is called **rated ripple current** (I_R).

The rated ripple current is specified in the relevant detail specifications at 100 or 120 Hz (in special cases at 100 kHz) and at upper category temperature.
Usually the rated ripple current will cause a temperature increase of the capacitor's surface of approximately 3 or 5 K (dependent on series) compared with ambient temperature. A further temperature increase of 3 or 5 K, will be found in the core of the capacitor.

This temperature rise is the result of the balance between heat generated by electric losses:

$$P = I_R^2 \text{ ESR}$$

and the carried off heat by radiation, convection and conduction:

$$P = \Delta T \,.\, A \,.\, \beta$$

where

ΔT = difference of temperature between ambient and case surface
A = geometric surface area of the capacitor
β = specific heat conductivity.

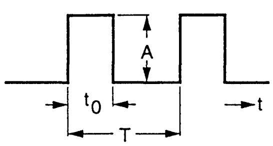
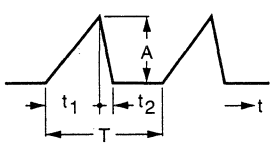
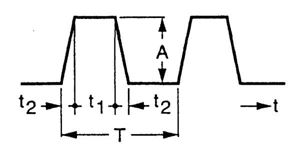
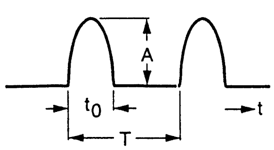
The heat, generated by ripple current, is an important factor of influence for non-solid electrolytic capacitors for calculating the useful life under certain circumstances.
In the detail specifications this factor is considered in the so-called "life-time nomograms" ("Multiplier of useful life" graph in the detail specifications) as a ratio between actual ripple current (I_A) and rated ripple current (I_R), drawn on the vertical axis.

Care should be taken to ensure that the actual ripple current remains inside the graph at any time of the entire useful life. If this cannot be realized, it is more appropriate to choose a capacitor from a higher voltage or higher capacitance, than originally required by the application.

Both the internal losses and the ripple current of electrolytic capacitors are frequency dependent. Therefore, a relevant frequency conversion table is stated in the detail specifications.

CALCULATION OF THE APPLICABLE RMS RIPPLE CURRENT

Non-sinusoidal ripple currents (if not accessible by direct measurement) have to be analyzed into a number of sinusoidal ripple currents by means of Fourier-analysis; the sum of the currents thus found may not exceed the applicable ripple current.
For some frequently occurring waveforms, approximation formulae are stated in Fig.11 for calculating the corresponding RMS value.

WAVE FORM	RMS VALUE
	$A\sqrt{\frac{t_0}{T}}$
	$A\sqrt{\frac{t_1+t_2}{3T}}$
	$A\sqrt{\frac{3t_1+2t_2}{3T}}$
	$A\sqrt{\frac{t_0}{2T}}$

MBC546 - 1

Fig.11 Approximation formulae for RMS values of non-sinusoidal ripple currents.

OPERATIONAL CONDITIONS

Charge-discharge proof

This term means the capability of capacitors to withstand frequent switching operations without significant change of capacitance.
Philips Al-electrolytic capacitors are charge-discharge proof in accordance with IEC 384-4/CECC 30 300: unless otherwise specified, 10^6 switching operations (R . C = 0.1 s) shall not cause a capacitance change of more than 10%.

If a capacitor is charged and discharged continuously several times per minute, the charge and discharge currents have to be considered as ripple currents flowing through the capacitor. The RMS value of these currents should be determined and the resultant value must not exceed the applicable limit.

Endurance test

In IEC 384-4 or CECC 30 300 the criteria for the acceptable drift of electrical parameters after the endurance test at U_R and upper category temperature are defined.
Test duration and conditions per series are stated in the relevant detail specification.

The endurance test does not provide information about the useful life of a capacitor, as no failure percentage is defined for this investigation.

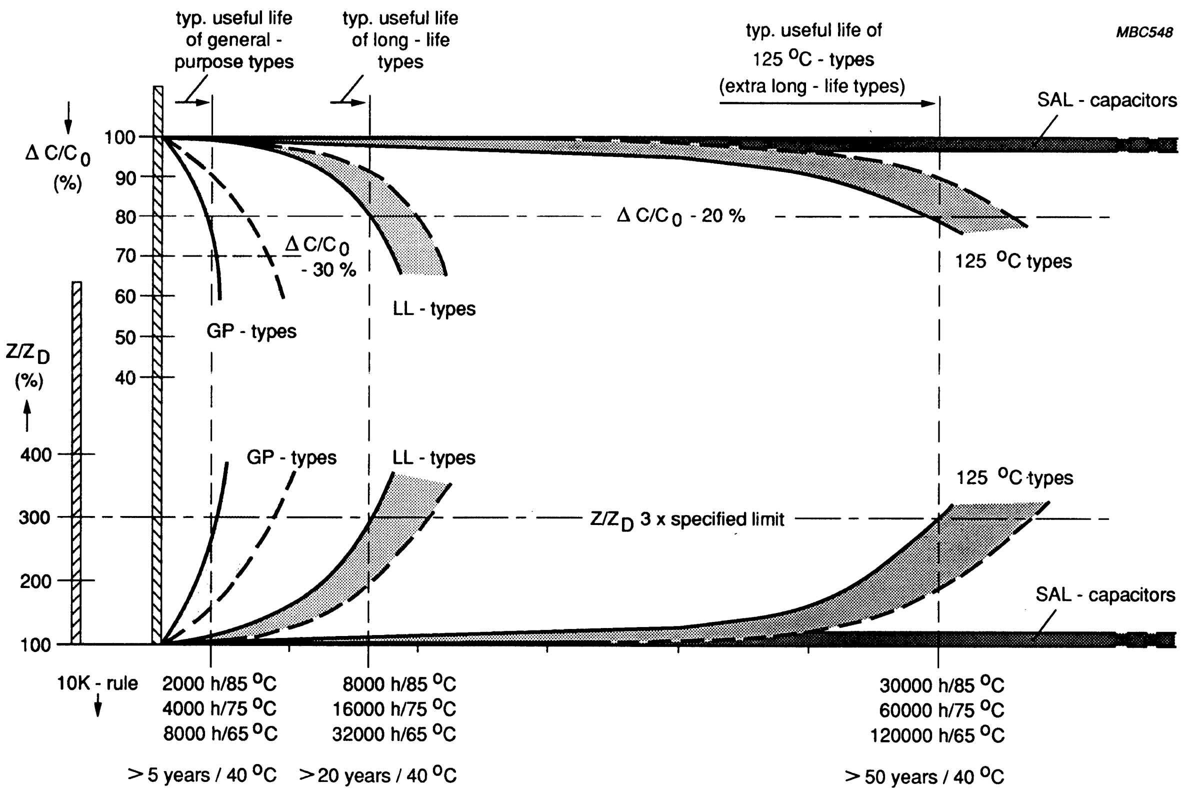
Useful life

Useful life (other names: load life, life time or typical life time) is that period of time, during which a given failure percentage may occur, under well defined conditions and requirements. Useful life data are usually calculated with a confidence level of 60%.

High quality of materials and controlled manufacturing processes provided, the useful life of non-solid electrolytic capacitors is solely determined by evaporation of electrolyte through the sealing.
Figure 12 shows the principal electrical consequences of this electrolyte loss: increasing impedance and decreasing capacitance at the end of useful life, for different non-solid (general purpose, long life and 125 °C types) and solid (SAL-) electrolytic capacitors. Tantalum (Ta) capacitors show similar behaviour to SAL-capacitors.

The influence of temperature on useful life is indicated by the so-called "10 K-rule" under the horizontal axis of the graph. The "10 K-rule" means approximately, that double the life time can be expected per 10 K temperature decrease; this principle is derived from the well known law of Arrhenius about acceleration of reaction processes.

The exact temperature dependence of useful life for a particular range is given in the corresponding detail specification in the "life-time nomogram" ("Multiplier of useful life" graph in the detail specifications). Detailed performance requirements, on which the definition



C_0 = initial value of capacitance.

Z_D = specified limit of impedance.

Fig.12 Principal trend of electrical parameters during useful life of different electrolytic capacitors.

"useful life" is based, are also stated in the relevant detail specifications.

Exceeding those requirements shall not necessarily induce a malfunction of the equipment involved. The performance requirements offer advice on the choice of components and design of the circuitry.

CALCULATION OF USEFUL LIFE BY MEANS OF "LIFE-TIME NOMOGRAMS"

Based on the Arrhenius law and on experience for some decades, a nomogram is specified in the detail specification for each range, where the influence of ambient temperature and ripple current on the expected useful life is shown.
The ratio of ripple current (I_A/I_R) is plotted on the vertical axis and the ambient temperature (T_{amb}) on the horizontal.

At the intersection of these two operational conditions the appropriate multiplier (correction factor) for useful life can be read. The useful life under certain conditions shall be calculated by multiplying (or dividing respectively) the specified useful life, with the resultant correction factor.

The useful life determined by this procedure is normally valid for applications without forced cooling. Under certain conditions and with additional cooling, the useful life may be considerably extended.

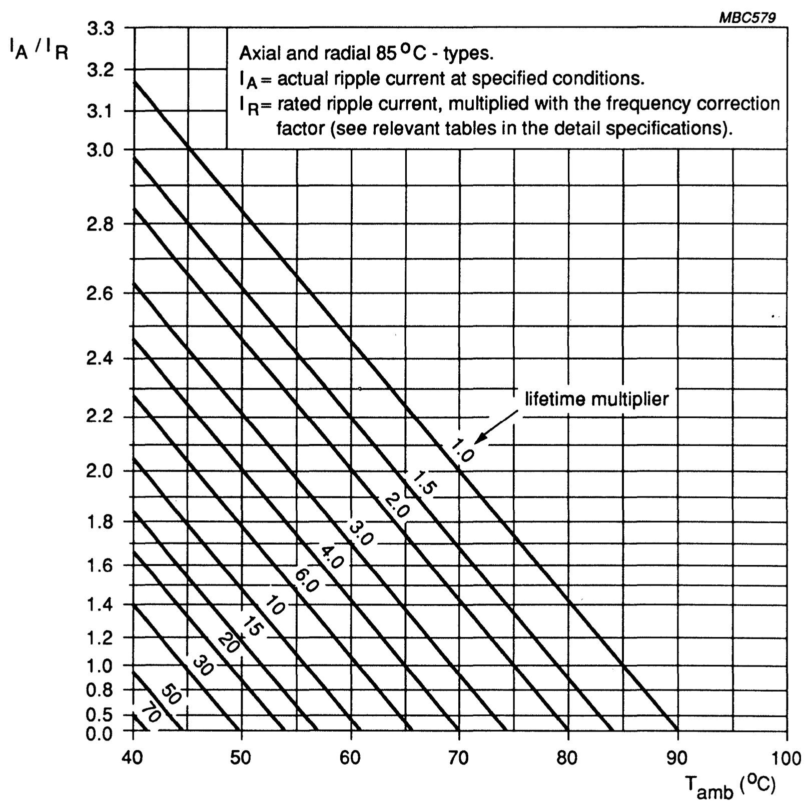


Fig.13 Typical example of a life-time nomogram: useful life as a function of ambient temperature and ripple current load (I_A/I_R); 85 °C types.

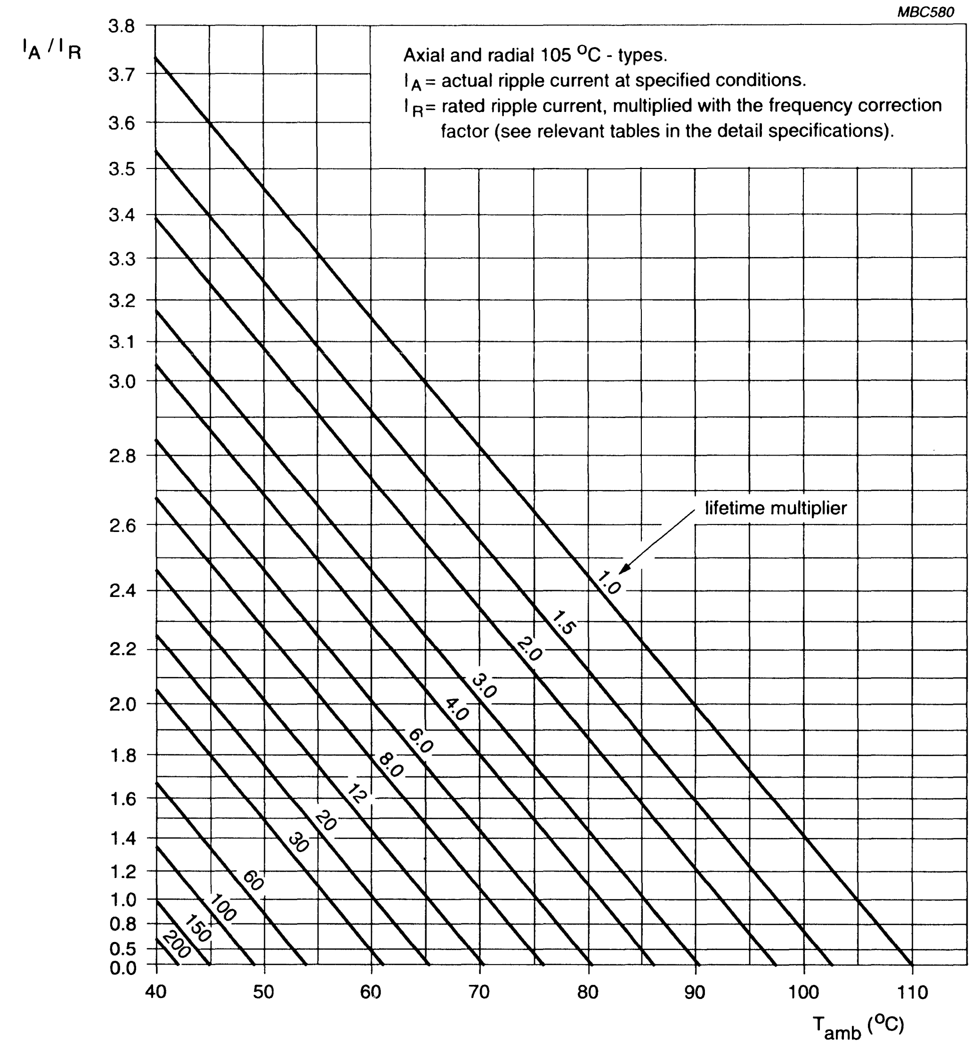


Fig.14 Typical example of a life-time nomogram: useful life as a function of ambient temperature and ripple current load (I_A/I_R); 105 °C types.

EXAMPLES FOR USE OF THE "LIFE-TIME NOMOGRAMS"

Example 1

Temperature in (operating) equipment is 45 °C

Ripple current load is exactly the rated value (thus: $I_A/I_R = 1$)

Which useful life can be expected (without pause and storage times):

a) for a capacitor with a specified useful life of 2000 hours/85 °C?

b) for a capacitor with a specified useful life of 2000 hours/105 °C?

Solution:

The corresponding life-time multiplier may be found at the intersection between the vertical "45 °C" - line and the horizontal "1" - line. For the 85 ° type this is "30" and for the 105 °C type it is "90".

Resulting useful life is thus:

a) for 85 °C type: 30 x 2000 hours = 60 000 hours or about 7 years

b) for 105 °C type: 90 x 2000 hours = 180 000 hours or about 20 years

Example 2

Which life time requirement has to be fulfilled by the capacitors, if the equipment life shall be 10 years (approx. 100 000 hours), consisting of 1000 hours/75 °C + 9000 hours/65 °C + 90 000 hours/40 °C? No ripple current applied (thus: $I_A/I_R = 0$).

Solution:

The mentioned life-times shall be converted to specified 85 °C or 105 °C life-times, i.e. they have to be divided through the correction factors found at the intersection of the respective operational conditions (see Table 3):

The required life-time can be fulfilled by types with a specified useful life of:

a) >2970 hours at 85 °C i.e. a 3000 hours/85 °C type, or

b) >935 hours at 105 °C i.e. a 1000 hours/105 °C type.

Example 3

Which internal temperature may occur in the equipment, if the actual ripple current is 2.5 times higher than the specified ripple current (thus: $I_A/I_R = 2.5$) and the load limit may not be exceeded?

Solution:

The load limit is defined by the diagonal line "multiplier 1" in the relevant nomogram.
This means here: the vertical line on the intersection of $I_A/I_R = 2.5$ and the multiplier 1 - line shows the maximum permitted internal temperature:

a) for 85 °C types this is max. 59 °C

b) for 105 °C types this is max. 79 °C

The corresponding life-time in this case is equal to the specified useful life.

Table 3

LIFE CONDITIONS	85 °C TYPES	105 °C TYPES
1000 hours at 75 °C	1000/2.9 = 345 hours	1000/8 = 125 hours
9000 hours at 65 °C	9000/6 = 1500 hours	9000/20 = 450 hours
90 000 hours at 40 °C	90 000/80 = 1125 hours	90 000/250 = 360 hours
	sum for 85 °C = **2970** hours	sum for 105 °C = **935** hours

Failure rate (λ)

The failure rate is defined by the number of components failing within a unit of time, related to the total quantity of components observed:

$$\lambda = \frac{\textit{number of failures (statistical upper limit 60\%)}}{\textit{total number of components} \times \textit{duration}}$$

The failure rate (λ) is generally expressed in so-called "fit" (failure in time) = 10^{-9}/hours with an upper confidence level (UCL) of 60%. It is calculated from results of periodical tests in the quality laboratories or derived from field observations respectively.

Usually the failure rate during time shows the well known "bathtub" curve (see Fig.15):

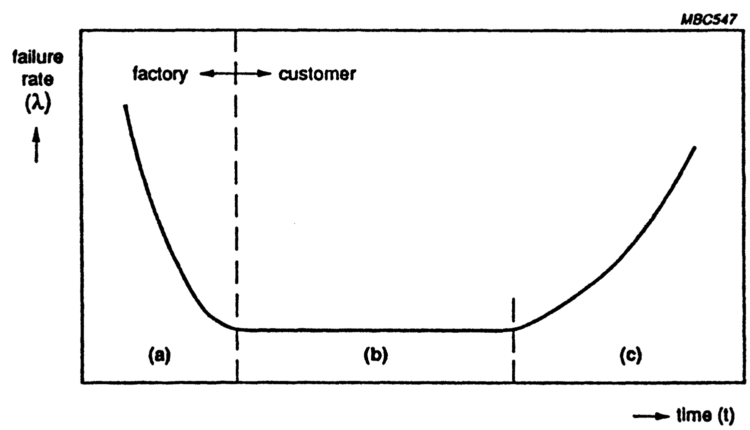
There are 3 periods in a typical capacitor life cycle:

a) Initial failure period, showing a rapidly decreasing failure rate. During production of Philips electrolytic capacitors, initial failures are removed after re-forming (which is a short burn-in); all capacitors shipped, have passed burn-in.

b) Random failure period, showing a low and constant failure rate. This period is identical with "useful life". The sum total of all (drift and accident) failures during this period, related to the total number of observed capacitors, is called "failure percentage". Both are specified in the detail specification of the relevant series.

c) Wear-out failure period, showing an increasing failure rate due to gradual deterioration.

Since the failure rate mainly depends on two stress factors (temperature and applied voltage), it is usually specified under reference conditions, which are: T_{amb} = 40 °C and U = 0.5 U_R.



a) initial failure period ("infant mortality")
b) random failure period (= useful life period)
c) wear-out failure period.

Fig.15 Failure rate (λ) as a function of time ("bathtub" curve).

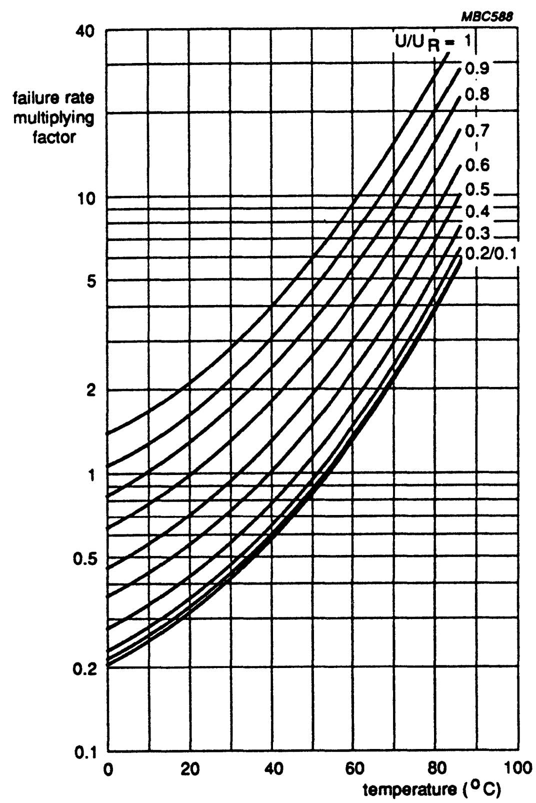


Fig.16 Conversion factors for failure rate (λ) as a function of ambient temperature (T_{amb}) and voltage ratio (U/U_R) for non-solid electrolytic capacitors.

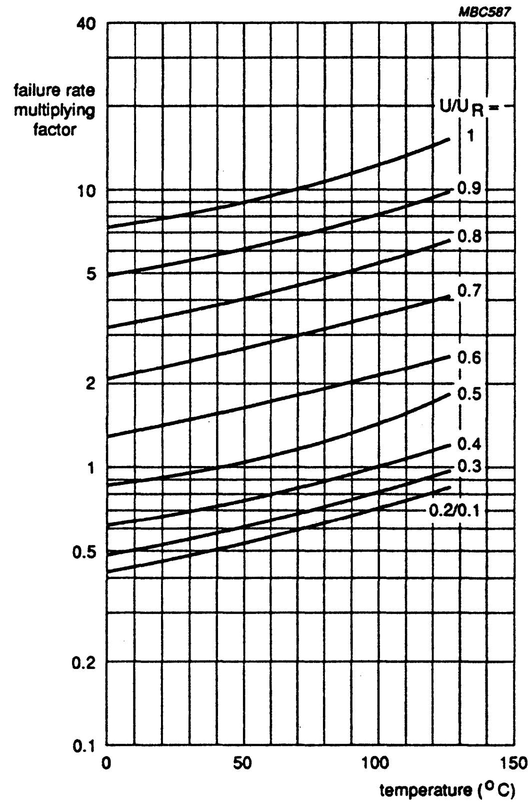


Fig.17 Conversion factors for failure rate (λ) as a function of ambient temperature (T_{amb}) and voltage ratio (U/U_R) for SAL electrolytic capacitors.

For other operational conditions, λ has to be converted correspondingly with the aid of Figs 16 and 17, failure rates as a function of stress factors (T_{amb} and U/U_R) for non-solid and SAL electrolytic capacitors.
Figure 16 is identical to Mil-Std 217, whereas Fig.17 has been derived from extended long term statistics compiled over 25 years by our test and quality laboratories.

Climatic category

For each capacitor range the climatic category in accordance with IEC 68-1 is stated in the relevant detail specification. The climatic category consists of three digit groups, having the following meaning:

Example:	40	085	56	
	40			lower category temperature (here: –40 °C)
		085		upper category temperature (here: +85 °C)
			56	duration of test "damp heat, steady state" (here: 56 days)

Application class

In DIN 40040 some application classes for climatic working conditions of components are defined, consisting of 3 code letters with the following meaning:

1st letter: lower category temperature
F: –55 °C; G: –40 °C; H: –25 °C

2nd letter: upper category temperature
P: +85 °C; M: +100 (+105) °C; K: +125 °C

3rd letter: maximum humidity conditions (see Table 4)

Likewise, if axial or radial types are subject to high ripple load, they shall be mounted with sufficient distance (e.g. ≥10 mm) from each other for good convection.

ELECTRICAL

Parallel connection

Al-electrolytic capacitors may be connected in parallel, but for safety reasons, large sizes should be individually guarded against sudden energy discharge of the whole battery due to a defective specimen.
With smaller batteries, this safeguarding is sufficiently ensured by current limiting resistors.

Table 4 Maximum humidity condition indication

CODE LETTER	RELATIVE AIR HUMIDITY			
	yearly average	**30 days per year**	**occasionally**	**dewing**
C	≤95%	100%	100%	permitted
D	≤80%	100%	90%	permitted
E	≤75%	95%	85%	slightly/rarely
F	≤75%	95%	85%	not permitted

MOUNTING

Mounting position of non-solid Al-electrolytic capacitors

Snap-in and printed wiring (PW) power electrolytic capacitors, in addition to the larger case sizes of axial and radial types, are normally equipped with a safety vent in the aluminium case. These and all smaller case size types, may be mounted in any position.

Screw-terminal and solder-lug power electrolytic capacitors have a safety vent in the sealing disc. These types shall be mounted so that if the vent is opened, no electrolyte or vapour may reach either the conductors under voltage or other parts of the printed circuit board. Vertical (vent up) or horizontal mounting position is recommended.

Design rules for "capacitor batteries"

MECHANICAL

Philips "large type" electrolytic capacitors are mainly used in power supply applications under high ripple current load. In these circumstances, the capacitors must be mounted with a distance of ≥15 mm from each other, in order to allow sufficient air circulation and to prevent mutual radiation.

Series connection

Al-electrolytic capacitors may be connected in series, bu when doing so it should be noted that the voltage distribution will be according to their leakage currents. This phenomenon may induce irregularities in voltage load and cause maximum ratings to be exceeded; this could have drastic consequences, especially with high voltage capacitors.
Series-connected electrolytic capacitors should therefor be, either supplied by galvanically separated voltage sources or the voltages shall be proportionally distribute by balancing resistors.

The balancing resistors can be dimensioned in accordance with the following approximation formula:

$$R_{sym}\ (\text{in k}\Omega) = 10\,000/C_R\ (\text{in }\mu\text{F})$$

Combined series/parallel connection

The above mentioned rules for both series and parallel connection are accordingly valid for any combination of these two cases.

MARKING

Philips electrolytic capacitors are identified in accordance with IEC rules. When sufficient space is available, capacitors are marked with the following details:

Table 5 Marking

Rated capacitance	in µF (the "µ" sign represents the position of the decimal point)
Rated voltage	in V
Tolerance on rated capacitance	if necessary, as a lettercode in accordance with IEC 62, e.g. T for −10/+50% M for ±20% K for ±10% Q for −10/+30% A for tolerance according to detail specification
Group number	3 digit part of the catalogue number, e.g. 036 for RSP series
Name of manufacturer	PHILIPS
Date code	abbreviation in 2 digits (IEC 62), e.g. 1st digit: U = 1987; V = 1988; W = 1989; A = 1990; B = 1991; C = 1992; D = 1993 2nd digit: 1 = January; 2 = February; ...; 9 = September; O = October; N = November; D = December example: A5 = produced in 1990, May production date may also be stated as year/week code: example: 9125 = produced in 1991, 25th week Date code for axial types 10 x 30 to 21 x 40 is stamped in the case next to cathode terminal
Factory code	indicating the factory of origin

Philips Components 6071 St. Andrews Road, Columbia, SC 29212-3198 (803) 772-2500 FAX: (803) 772-2445

WARNING

Correct application and strict adherence to the important information listed below, will ensure optimum performance of the capacitors over their entire specified useful life.
Please note, that ignoring these rules may reduce the equipment life time or even destroy the capacitor, together with parts of the equipment or property involved. The consequences may be a short or open circuit of the component, or heat generation. Opening of the case or vent (danger of injury) may be regarded as hazardous and cause liquids, vapours or dust to be released. Similar precautions should be taken when testing electrolytic capacitors.
Please consult your local Philips Components sales organization, if one or more of these limits cannot be adhered to.

PARAMETER	IMPORTANT INFORMATION – PRODUCT SAFETY	MORE DETAILS
POLARITY, REVERSE VOLTAGE	**Electrolytic capacitors for DC applications require polarization.** Check the polarity of each capacitor: both in circuit design and in mounting (polarity is clearly indicated on the capacitor). For short periods a limited reverse voltage is allowed (see detail specification); for conditions and maximum parameter changes see Tests and Requirements. Exceeding reverse voltage may result in early failures.	detail specification, TESTS AND REQUIREMENTS
VOLTAGE	**Do not apply a voltage exceeding the capacitor's voltage rating.** Check the maximum voltage across the capacitor which can occur over the whole equipment life. In normal operation the rated voltage of the capacitor shall not be exceeded; if so, early failures may occur. However, for short periods the voltage may be raised up to surge voltage value (see detail specification); for conditions and maximum parameter changes see Tests and Requirements	detail specification, TESTS AND REQUIREMENTS
RIPPLE LOAD	**Do not allow excessive ripple current to pass.** The rated ripple current given for certain conditions (temperature, frequency and useful life) shall not be exceeded. If so, early failure may result. **Keep ripple voltage within ratings.** The sum of DC-bias and maximum amplitude of ripple voltage shall be within rated voltage and 0 V. Electrolytic capacitors are not normally designed for AC application	detail specification
TEMPERATURE RANGE	**Use capacitors within specified temperature range.** Applicable temperature range is given in the relevant detail specification. A general principle is that lower ambient temperature means longer life; therefore, electrolytic capacitors should be placed at the coolest positions on the board, wherever possible. Exceeding the permitted temperature range may cause early failures	detail specification
CHARGE-DISCHARGE	**Observe charge-discharge limitations.** Frequent charge-discharge load via low resistance may cause capacitance drop or destroy the capacitor. Under well defined conditions (see Tests and Requirements) frequent charge-discharge operation is allowed. The resulting current through the capacitor may not exceed the ripple current limit.	TESTS AND REQUIREMENTS

PARAMETER	IMPORTANT INFORMATION – PRODUCT SAFETY	MORE DETAILS
SERIES/ PARALLEL CONNECTIONS	**When connecting in series/parallel, apply corresponding design rules.** Connecting electrolytic capacitors in series/parallel is possible, provided that balancing resistors are applied to each capacitor, in order to stabilize the voltage over each individual capacitor. Rules for correct design are given in the introduction	INTRODUCTION
PROTECTIVE RESISTOR	**For tantalum electrolytic capacitors a protective resistor is required.** When using tantalum electrolytic capacitors, consider the appropriate series resistor for current limitation under certain circumstances.	detail specification
INSULATION	**The capacitor case is not insulated from the cathode terminal.** Axial capacitors have a direct contact between case and cathode terminal; radial and power capacitors exhibit an indeterminate resistance between the cathode terminal and the metal case. Metal parts other than terminals should never make contact to conducting tracks or metal parts of other components. Dummy pins are connected to the cathode.	
STORAGE	**Excessive storage time or conditions may have adverse effects on capacitors.** Capacitors should be stored at room temperature, low humidity and out of direct sunlight. Storage at elevated temperature and/or high relative humidity may have a negative influence to taping accuracy, solderability, leakage current and life expectancy.	INTRODUCTION TESTS AND REQUIREMENTS
HIGH AIR PRESSURE	**Do not expose capacitors to overpressure.** Maximum operating pressure is 150 kPa. Higher pressure may cause a short circuit.	
LOW AIR PRESSURE	**The capacitors may be used at an altitude ≤ 12 000 m.** Minimum air pressure: 8.6 kPa	TESTS AND REQUIREMENTS
MOUNTING	**Avoid excessive stress to the lead wires or terminals.** Excessive stress can be caused by component processing machines if lead wires are not sufficiently fixed during bending, cutting, cropping or inserting operations. Other possible reasons are incorrect hole distance at PC boards or bending of the component after soldering. For maximum allowed mechanical load see Tests and Requirements. Mechanically damaged capacitors may not be used. Safety vent should have enough space to function correctly.	TESTS AND REQUIREMENTS
SOLDERING	**Keep soldering temperature and time under control.** For maximum soldering conditions see Tests and Requirements. Additional temperature load e.g. for curing the glue of SMD's are allowed to a certain limit, which depends on series and exact details, please apply to your sales engineer for your specific conditions. Molten solder or the soldering iron should not make contact with the capacitor's insulation.	TESTS AND REQUIREMENTS

PARAMETER	IMPORTANT INFORMATION – PRODUCT SAFETY	MORE DETAILS
BOARD CLEANING	**Halogenated cleaning agents may damage electrolytic capacitors.** Non-solid aluminium electrolytic capacitors may be affected adversely when in contact with halogenes, e.g. chlorine, fluorine, or chemicals containing halogene. Thereby, internal corrosion may be started with retarded effects as leakage current increase, open or short circuit, opening of case or vent. Therefore halogenated solvents are harmful for electrolytic capacitors; consequently, water-based or alcohol-based cleaning agents are preferable. If unavoidable, do not exceed recommended exposure times and make provision for thorough drying - especially if the board is laquered or embedded afterwards.	
ADHESIVES, COATING MATERIALS	**Some adhesives and coating materials affect capacitors adversely.** For varnishing, coating, laquering, embedding or glueing at the capacitor's sealing, ensure that the materials used are halogene-free in all their constituent parts (base material, thinners, binders, reacting agents, propellants, additives). For reasons see BOARD CLEANING above.	
DISPOSAL	**Electrolytic capacitors are subject to special waste regulations.** Aluminium and tantalum electrolytic capacitors are free from PCB- or PBDE-containing substances. Dioxines or furanes are not constituent parts of electrolytic capacitors. However, because of other polluting ingredients, larger quantities (in weight) of electrolytic capacitors are subject to special waste regulations in accordance with the relevant national laws. In general, electrolytic capacitors have to be disposed under controlled circumstances in a high temperature incinerator at minimum 900 °C.	
PERSONNEL SAFETY	**WARNING NOTE.** Non-solid electrolytic capacitors may contain chemicals which can be regarded as hazardous if handled incorrectly. Caution is necessary if the outer case is fractured; vapours or dust particles should not be inhaled (good ventilation is essential); skin, eye or clothing contact with liquids should be avoided. In case of such contact, flush thoroughly with running water as soon as possible, then wash skin or clothing with soap and water or a mild detergent. Any possible discolouration of the wetted skin will disappear after a few days. In the event of fire, the organic parts of electrolytic capacitors may release such constituents as carbon monoxide, nitric oxides or dust particles; take caution when breathing-in.	

This chapter contains an abridged version of tests and requirements given in IEC 384-4 or CECC 30 300 respectively. Series specific tests and requirements are given in the relevant detail specification.

Table 1 Non-solid Aluminium

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Robustness of terminations	4.4			
Tensile strength		Ua	leaded types: loading force 10 N for 10 s power types: loading force 20 N for 10 s	no visible damage
Bending		Ub	leaded types: loading force 5 N, two consecutive bends	no visible damage
Torsion		Uc	leaded types, axial: two successive rotations of 180° in opposite direction, 5 s per rotation	no visible damage
Torque on nut (stud)		Ud	power types/screw terminal: torque of 1.76 Nm gradually applied	no visible damage
Resistance to soldering heat	4.5	Tb (method 1A)	solder bath: 260 °C, 10 s, for capacitors with printed-wiring pins	no visible damage, marking legible; ΔC/C ≤5%
		Tb (method 1B)	solder bath: 350 °C, 3.5 s for capacitors with solder leads or tags	
Solderability	4.6	Ta	solder bath: 235 °C, 2 s; for capacitors with printed-wiring pins, 270 °C, 2 s; for capacitors with solder leads or tags, immersed up to 2 mm from the body; activated flux: 600/0.2% Cl	no visible damage, marking legible; ≥95% tinning
Rapid change of temperature	4.7	Na	5 cycles of 3 hours at lower and upper category temperature	no visible damage, no leakage of electrolyte
Vibration	4.8	Fc	long-life grade types: 10 to 500 Hz, 0.75 mm or 10 g (whichever is less), 3 directions, 2 hours per direction	no visible damage, no leakage of electrolyte, marking legible; ΔC/C ≤5% with respect to initial measurements
			general-purpose grade types: 10 to 55 Hz, 0.75 mm or 10 g (whichever is less), 3 directions, 2 hours per direction (Form MR types only)	

(continued)

Table 1 Non-solid Aluminum (continued)

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Bump	4.9	Eb	long-life grade types: 40 g, 2 directions, 4000 bumps total	no visible damage, no leakage of electrolyte; ΔC/C ≤5% with respect to initial measurement
			general-purpose grade types: 40 g, 2 directions, 1000 bumps total	
Climatic sequence	4.11			
Dry heat	4.11.1	Ba	16 hours at upper category temperature, no voltage applied	no visible damage, no leakage of electrolyte
Damp heat, cyclic	4.11.2	Db	1 cycle of 24 hours at 55 ± 2 °C, RH 95 to 100%, no voltage applied	
Cold	4.11.3	Aa	2 hours at lower category temperature, no voltage applied	no visible damage, no leakage of electrolyte
Low air pressure	4.11.4	M	5 minutes at 15 to 35 °C, at atmospheric pressure of 85 mbar, U_R applied during last minute	no visible damage, no evidence of breakdown or flashover
Damp heat, cyclic	4.11.5	Db	5 cycles of 24 hours at 55 ± 2 °C, RH 95 to 100%, no voltage applied	
Sealing	4.11.6	Qc	1 minute in water at 90 °C	no continuous chain of bubbles
	4.11.7		final measurement after climatic sequence	no visible damage, no leakage of electrolyte, marking legible; leakage current ≤stated limit, tan δ ≤1.2 x stated limit; ΔC/C ≤10%
Damp heat, steady state	4.12	Ca	56 days at 40 °C, RH 90 to 95%, no voltage applied	no visible damage, no leakage of electrolyte, marking legible; leakage current ≤stated limit, tan δ ≤1.2 x stated limit, insulation resistance >100 MΩ, no breakdown or flashover below 1000 V
				long-life grade types: ΔC/C ≤10%
				general-purpose grade types: ΔC/C ≤20%

(continued)

Table 1 Non-solid Aluminum (continued)

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Endurance	4.13		for test duration, refer to the relevant data sheet in this handbook; at upper category temperature, U_R applied	no visible damage, no leakage of electrolyte, marking legible; leakage current ≤stated limit, insulation resistance >100 MΩ, no breakdown or flashover below 1000 V
				long-life grade types: U_R ≤6.3 V: ΔC/C +15/–30% U_R 10 to 160 V: ΔC/C ±15% U_R ≥200 V: ΔC/C ±10% tan δ ≤1.3 x stated limit, impedance ≤2 x stated limit
				general-purpose grade types: U_R ≤6.3 V: ΔC/C +25/–40% U_R 10 to 160 V: ΔC/C ±30% U_R ≥200 V: ΔC/C ±15% tan δ ≤1.5 x stated limit or 0.40 (whichever is greater), impedance ≤3 x stated limit
Surge	4.14		from source of 1.15 x U_R for U_R ≤315 V or 1.1 x U_R for >315 V, RC = 0.1 ±0.05 s, 1000 cycles of 30 s on, 330 s off	no visible damage, no leakage of electrolyte; leakage current ≤stated limit, tan δ ≤stated limit, ΔC/C ≤15%
			long-life grade types: at upper category temperature	
			general-purpose grade types: at 25 °C	
Reverse voltage	4.15		1 V in reverse polarity followed by U_R in forward polarity, both for 125 hours at upper category temperature	leakage current ≤stated limit, tan δ ≤stated limit, ΔC/C ≤10%
Pressure relief (for types with vent only)	4.16		DC voltage applied in reverse direction producing a current of 1 to 10 A	pressure relief opens prior to danger of explosion or fire
Storage at upper category temperature	4.17	Ba	for test duration, refer to the relevant data sheet in this handbook; at upper category temperature	no visible damage, no leakage of electrolyte; leakage current ≤2 x stated limit, tan δ ≤1.2 x stated limit, ΔC/C ≤10%

(continued)

Table 1 Non-solid Aluminum (continued)

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Storage at low temperature	4.18	Ab	72 hours at a temperature of 15 °C below the lower category temperature	no visible damage, no leakage of electrolyte; leakage current ≤stated limit, tan δ ≤stated limit, $\Delta C/C \leq 10\%$
Characteristics at high and low temperature	4.19		step 1: reference measurement at 20 °C of capacitance, impedance and tan δ at 100 Hz	
		Aa	step 2: measurement at lower category temperature	Impedance at 100 Hz ≤7 x value of step 1 for $U_R \leq 6.3V$ or $U_R > 160$ V, ≤5 x value of step 1 for $6.3 < U_R \leq 16$ V, ≤4 x value of step 1 for $16 < U_R \leq 160$ V
		Ba	step 3: measurement at upper category temperature	leakage current ≤10 x stated limit at 125 °C ≤8 x stated limit at 105 °C ≤5 x stated limit at 85 °C ≤3 x stated limit at 70 °C
Charge and discharge	4.20		for $U_R \leq 160$ V: 10^6 cycles of 0.5 s charge to U_R (RC = 0.1 s) and 0.5 s discharge (RC = 0.1 s). for $U_R > 160$ V: under consideration	no visible damage, no leakage of electrolyte; $\Delta C/C \leq 10\%$

Table 2 Solid Aluminium types

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Robustness of terminations	4.4			
Tensile strength		Ua	loading force: 10 N for 10 s	no visible damage
Bending		Ub	loading force: 5 N, two consecutive bends	no visible damage
Torsion (axial types)		Uc	two successive rotations of 180° in opposite direction, 5 s duration per rotation	no visible damage
Resistance to soldering heat	4.5	Tb (method 1A)	radial types: solder bath 260 °C for 10 s	no visible damage, markings legible; $\Delta C/C \leq 5\%$ with respect to initial measurement
		Tb (method 1B)	axial types: solder bath 350 °C for 3.5 s	
Solderability	4.6	Ta (method 1)	solder bath 235 °C for 2 s, immersed up to 2 mm from the body, activated flux 600 (0.2% Cl.)	no visible damage, marking legible; ≥95% tinning
Rapid change of temperature	4.7	Na	5 cycles of 30 minutes at lower and upper category temperature	no visible damage; leakage current (notes 1 and 4), tan δ and Z ≤stated limit
Vibration	4.8	Fc	10 to 500 Hz, 0.75 mm or 10 g (whichever is less severe), in 3 directions, 2 hours per direction	no visible damage, markings legible; $\Delta C/C \leq 5\%$ with respect to initial measurement
			SAL-AG 123: 10 to 2000 Hz, 1.5 mm or 20 g (whichever is less severe) in 3 directions, 2 hours per direction	no visible damage, markings legible; $\Delta C/C \leq 5\%$ with respect to initial measurement
Bump	4.9	Eb	40 g, 2 directions 4000 bumps total	no visible damage; $\Delta C/C \leq 5\%$ with respect to initial measurement
Shock	4.10	Ea	SAL-AG 123: acceleration: 29 400 m/sec^2 or 3000 g duration of pulse: 0.2 ms total number of shocks: 18	no visible damage; $\Delta C/C \leq 5\%$ with respect to initial measurement

Table 2 Solid Aluminum (continued)

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Climatic sequence	4.11			
Dry heat	4.11.1	Ba	16 hours at upper category temperature, no voltage applied	
Damp heat, cyclic	4.11.2	Db	1 cycle between 55 °C and 25 °C, 24 hours duration, 95 - 100% RH, no voltage applied	
Cold	4.11.3	Aa	2 hours at lower category temperature, no voltage applied	
Low air pressure	4.11.4	M	5 minutes at 25 + 10 °C atmospheric pressure: 8.5 kPa, U_R applied during last minute of test	no breakdown, flashover, or harmful deformation of case
Damp heat, cyclic	4.11.5	Db	5 cycles between 55 °C and 25 °C, 95 –100% RH, no voltage applied	
			final measurements after climatic sequence	no visible damage, markings legible; leakage current (notes 1 and 4) ≤stated limit, tan δ and Z ≤1.2 x stated limit
				axial types: ΔC/C ≤5% with respect to initial measurement radial types: ΔC/C ≤10% with respect to initial measurement

(continued)

Table 2 Solid Aluminum (continued)

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Endurance	4.13		for test duration, refer to the relevant data sheet in this handbook; at upper category temperature U_R applied (note 2)	no visible damage, markings legible; leakage current ≤stated limit, ΔC/C ≤10% with respect to initial measurement, tan δ and Z ≤1.2 times the stated limit
				axial types: insulation resistance ≥100 MΩ no breakdown or flashover at 1000 V
Endurance (additional) SAL-A			2000 hours at 155 °C, maximum 0.63 U_R applied	leakage current ≤stated limit, ΔC/C ≤20% with respect to initial measurement, tan δ ≤1.5 x stated limit, Z ≤2.5 x stated limit
Surge	4.14		applied voltage source of 1.15 U_R (note 2) at 125 °C, 1000 cycles, 30 s on, 330 s off	no visible damage; leakage current ≤stated limit, tan δ ≤stated limit
				axial types: ΔC/C ≤5% with respect to initial measurement
				radial types: ΔC/C ≤10% with respect to initial measurement
Reverse voltage	4.15		0.15 U_R (note 2) in reverse polarity at 125 °C, for 125 hours, followed by U_R (note 2) in forward polarity at 125 °C for 125 hours	leakage current ≤stated limit, ΔC/C ≤10% with respect to initial measurement, tan δ and Z ≤stated limit
Reverse voltage (additional) Radial types			0.30 U_R (note 2) in reverse polarity at 125 °C for 125 hours, followed by U_R (note 2) in forward polarity at 125 °C for 125 hours	leakage current (note 1) ≤stated limit, ΔC/C ≤10% with respect to initial measurement, tan δ and Z ≤stated limit
Reverse voltage (additional) SAL-A			0.30 U_R in reverse polarity at 85 °C for 125 hours, followed by U_R in forward polarity at 85 °C for 125 hours	leakage current (note 4) ≤stated limit, ΔC/C ≤10% with respect to initial measurement, tan δ and Z ≤stated limit

(continued)

Table 2 Solid Aluminum (continued)

NAME OF TEST	IEC 384-4/ CECC 30 300 sub clause	IEC 68-2 TEST METHOD	PROCEDURE (quick reference)	REQUIREMENTS
Storage at upper category temperature	4.17	Ba	96 ±4 hours at upper category temperature	no visible damàge; leakage current ≤stated limit, ΔC/C ≤5% with respect to initial measurement SAL-RPM ΔC/C ≤10% with respect to initial measurement
Long storage ≥1 year (additional)			at ambient temperature	leakage current (note 1) ≤stated limit
Characteristics at high and low temperature	4.19		step 1: reference measurement at 20 °C, of capacitance, tan δ and impedance at 100 Hz	
			step 2: measurement at –55 °C, capacitance, tan δ and impedance at 100 Hz	ΔC/C ≤20% with respect to value in step 1 impedance ratio (100 Hz): ≤2 x the value of step 1 tan δ ≤2 x the stated limit
			step 3: measurement at 125 °C, capacitance, leakage current (note 2), tan δ and impedance at 100 Hz	leakage current (notes 1 and 3) ≤ 15 x the stated limit, ΔC/C ≤20% of the value measured in step 1, tan δ ≤stated limit
Charge and discharge	4.20		10^6 cycles charging to U_R for 0.5 s, and then discharging for 0.5 s	no visible damage; ΔC/C ≤5% with respect to inital measurement

Notes

1. For capacitors type SAL-RP 122, the 15 s value of leakage current measured after 5 minutes.
2. 25 V for 40 V versions (capacitor type SAL-RP 122) and 30 V for 35 V and 40 V versions (capacitor type SAL-RPM 128).
3. For capacitors type SAL-RP 122, 40 V version, <8 x the stated limit.
4. For capacitors type SAL-A 123, leakage current after 5 minutes.

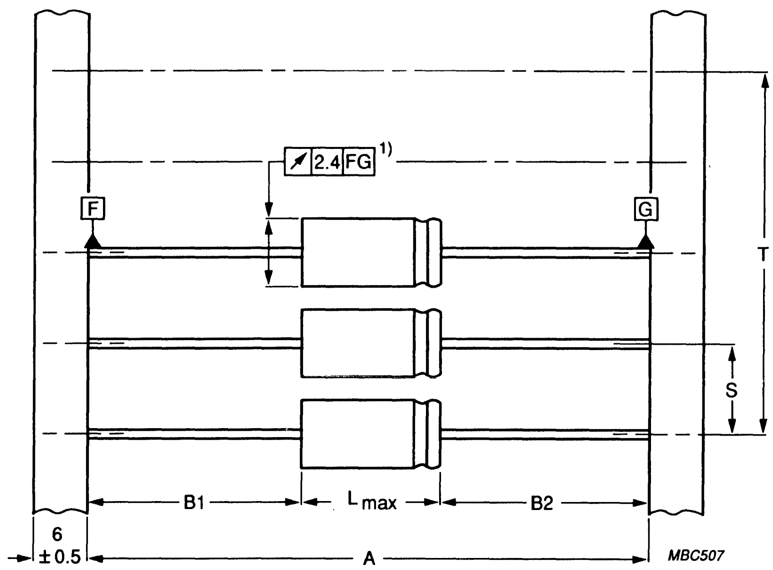
TAPING

Philips axial, solid and non-solid aluminium electrolytic capacitors in sizes up to ∅15 mm, are available in taped version corresponding to IEC 286-1.

They are most suitable for use on automatic insertion machines, cutting and forming equipment and are supplied in box (ammopack preferred), or on reel. For catalogue numbers, refer to the relevant detail specification.

Table 1 Taping dimensions

CASE SIZE ∅ D_{nom} x L_{nom}	CASE CODE	A (mm)	S (mm)	T for number (n)		L_{max} (mm)	C (mm)	D (mm)
				n<50	50<n<100			
Non-solid types								
3.3 x 8	1a	63.5 ±1.5	5 ±0.4	5(n-1) ±2	5(n-1) ±4	9	83.5	94.5
3.3 x 11	1	63.5 ±1.5	5 ±0.4	5(n-1) ±2	5(n-1) ±4	12	83.5	94.5
4.5 x 10	2	63.5 ±1.5	5 ±0.4	5(n-1) ±2	5(n-1) ±4	10.5	83.5	94.5
6 x 10	3	63.5 ±1.5	10 ±0.4	10(n-1) ±2	10(n-1) ±4	10.5	83.5	94.5
6.3 x 12.7	(2)	63.5 ±1.5	10 ±0.4	10(n-1) ±2	10(n-1) ±4	12.9	83.5	94.5
7.7 x 12.7	(3)	63.5 ±1.5	10 ±0.4	10(n-1) ±2	10(n-1) ±4	12.9	83.5	94.5
8 x 11	5a	63.5 ±1.5	10 ±0.4	10(n-1) ±2	10(n-1) ±4	11.5	83.5	94.5
6.5 x 18	4	73 ±1.6	10 ±0.4	10(n-1) ±2	10(n-1) ±4	18.5	88.5	99.5
6.5 x 25	4L	73 ±1.6	10 ±0.4	10(n-1) ±2	10(n-1) ±4	25	88.5	99.5
8 x 18	5	73 ±1.6	10 ±0.4	10(n-1) ±2	10(n-1) ±4	18.5	88.5	99.5
10 x 18	6	73 ±1.6	15 ±0.75	15(n-1) ±2	15(n-1) ±4	18.5	88.5	99.5
10 x 25	7	73 ±1.6	15 ±0.75	15(n-1) ±2	15(n-1) ±4	25.0	88.5	99.5
10 x 30	00	73 ±1.6	15 ±0.75	15(n-1) ±2	15(n-1) ±4	30.5	90	100
12.5 x 30	01	73 ±1.6	15 ±0.75	15(n-1) ±2	15(n-1) ±4	30.5	90	100
15 x 30	02	73 ±1.6	20 ±0.75	20(n-1) ±2	20(n-1) ±4	30.5	90	100
Solid types								
6.5 x 15	1	73 ±1.6	10 ±0.4	10(n-1) ±2	10(n-1) ±4	15.3	90	100
7.5 x 20	2A	73 ±1.6	10 ±0.4	10(n-1) ±2	10(n-1) ±4	20.4	90	100
9 x 22.5	4	73 ±1.6	10 ±0.4	10(n-1) ±2	10(n-1) ±4	23.3	90	100
10 x 31.5	5	73 ±1.6	15 ±0.75	15(n-1) ±2	15(n-1) ±4	32	90	100
12.5 x 31.5	6	73 ±1.6	15 ±0.75	15(n-1) ±2	15(n-1) ±4	32	90	100



Dimensions in mm.

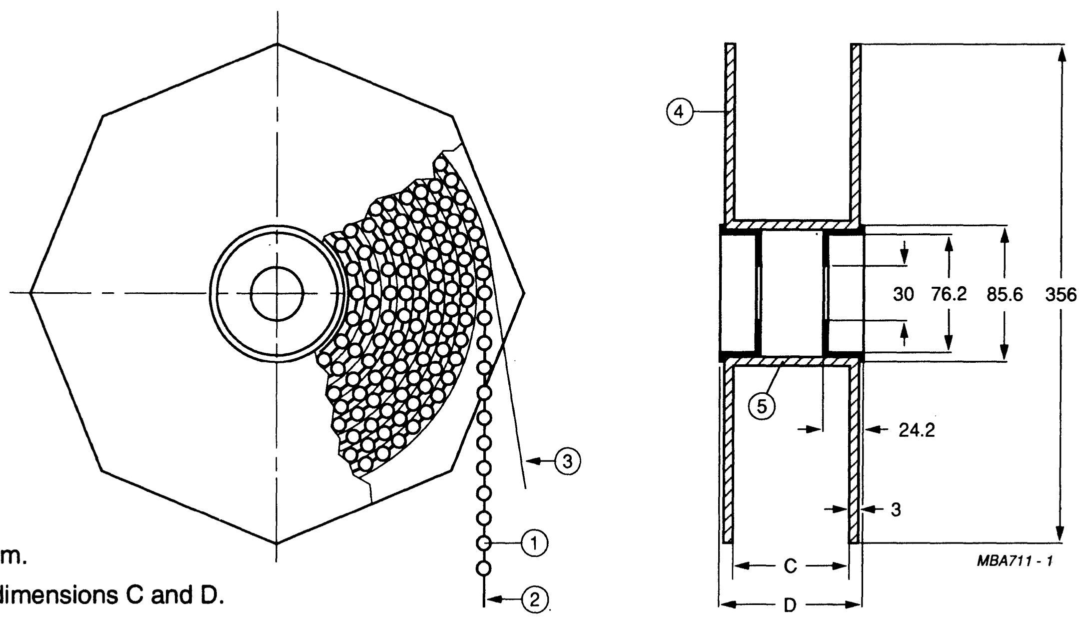
B1 – B2 = max. 1.4 mm.

The negative capacitor terminals are connected to the blue tape.

[1] not for case size 15 x 30.

See Table 1 for dimensions A,S,T and L.

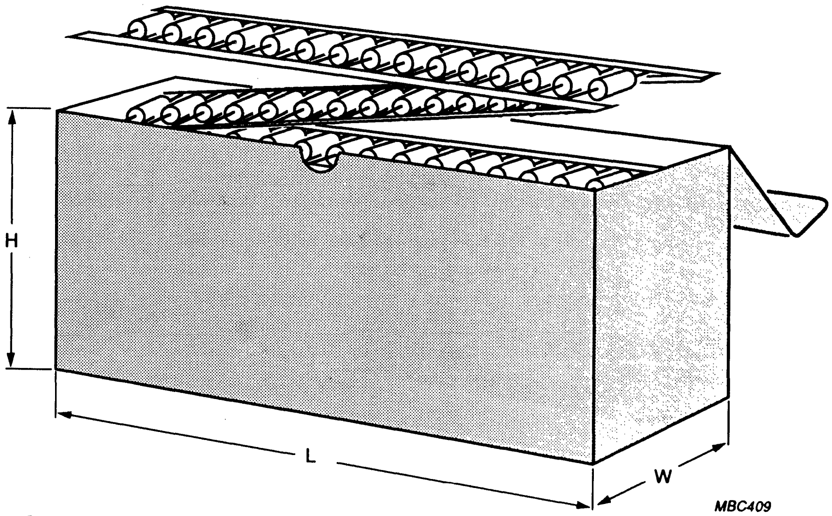
Fig.1 Axial capacitors on tape, case sizes 3.3 x 8 to 15 x 30 mm.



1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder.

Dimensions in mm.
See Table 1 for dimensions C and D.

Fig.2 Reel dimensions, case sizes 3.3 x 8 to 15 x 30 mm.



PREFERRED PACKING.

For dimensions L, W and H see Table 2.

Fig.3 Ammopack, case sizes 3.3 x 8 to 10 x 25 mm.

Table 2 Nominal outer dimensions of ammopack

CASE SIZE ∅ D_{nom} x L_{nom}	**CASE CODE**	**L (mm)**	**W (mm)**	**H (mm)**
Non-solid types				
3.3 x 8	1a	282	92	64
3.3 x 11	1	282	92	64
4.5 x 10	2	282	92	116
6 x 10	3	415	92	107
6.3 x 12.7	(2)	415	92	107
7.7 x 12.7	(3)	415	92	107
8 x 11	5a	415	92	107
6.5 x 18	4	415	98	127
6.5 x 25	4L	415	98	127
8 x 18	5	415	98	127
10 x 18	6	415	98	159
10 x 25	7	415	98	159

QUANTITIES per PACKING UNIT

Table 3 Number of capacitors per packing unit

CASE SIZE $\varnothing D_{nom} \times L_{nom}$	CASE CODE	AXIAL			SINGLE ENDED, Mounting Ring (bulk) Form MR
		TAPED IN AMMOPACK Form BA	TAPED ON REEL Form BR	BULK or PAPERSTRIP Form AA	
Non-solid types					
3.3 x 8	1a	1000	4000	–	–
3.3 x 11	1	1000	4000	–	–
4.5 x 10	2	1000	3000	–	–
6 x 10	3	1000	1000	–	–
6.3 x 12.7	(2)	1000	1000	–	–
7.7 x 12.7	(3)	500	500	–	–
8 x 11	5a	500	500	–	–
6.5 x 18	4	1000	1000	–	–
6.5 x 25	4L	1000	1000	–	–
8 x 18	5	500	500	–	–
10 x 18	6	500	500	–	–
10 x 25	7	500	500	–	–
10 x 30	00	–	500	200	–
12.5 x 30	01	–	400	200	–
15 x 30	02	–	250	200	200
18 x 30	03	–	–	200	200
18 x 40	04	–	–	100	100
21 x 40	05	–	–	100	100
Solid types					
6.5 x 15	1	–	800	100	–
7.5 x 20	2A	–	800	100	–
9 x 22.5	4	–	500	100	–
10 x 31.5	5	–	500	100	–
12.5 x 31.5	6	–	400	100	–

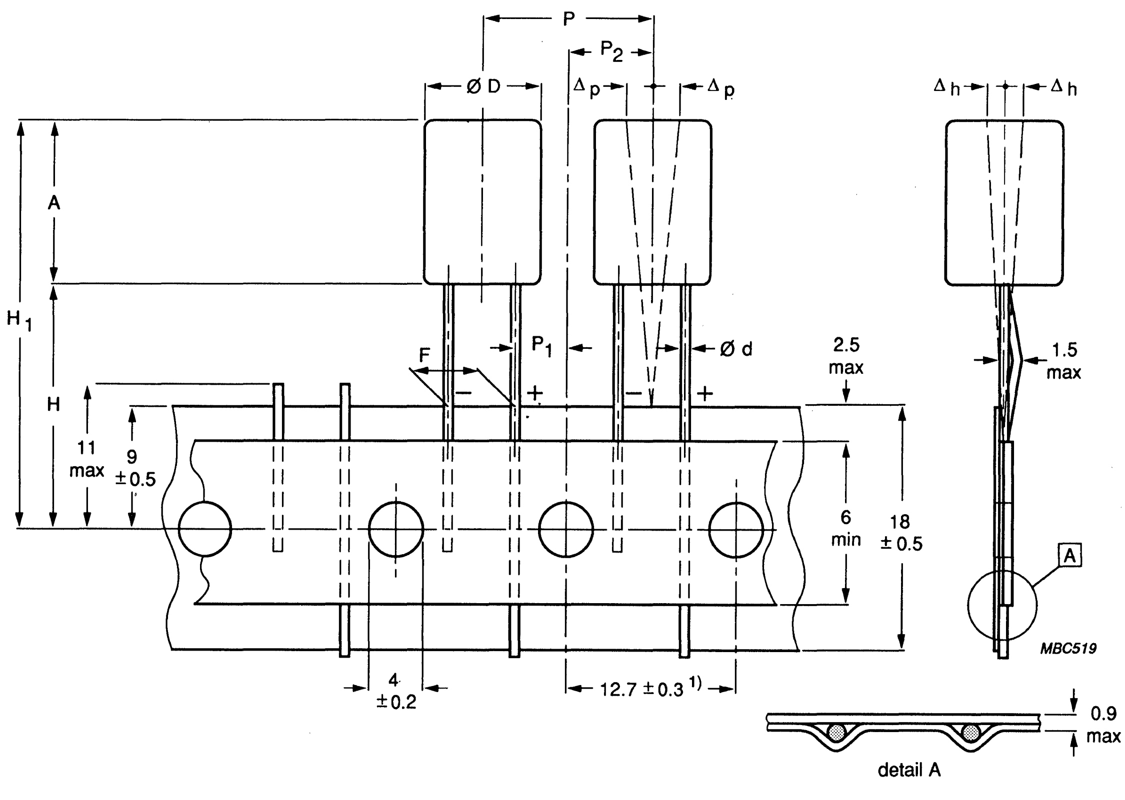
TAPING

Philips radial, solid and non-solid aluminium electrolytic capacitors in sizes up to ª 16 mm, are available in taped version corresponding to IEC 286-2 or JIS C 0805. They are most suitable for use on automatic insertion machines, mounting robots or cutting and forming equipment and are supplied in box (ammopack preferred), or on reel.

For catalogue numbers, refer to the relevant detail specification.

The information contained within this part is valid for the following series:

- **2222 116 . . . . .**



1) Tolerance over any 20 pitches: ±1.0 mm.

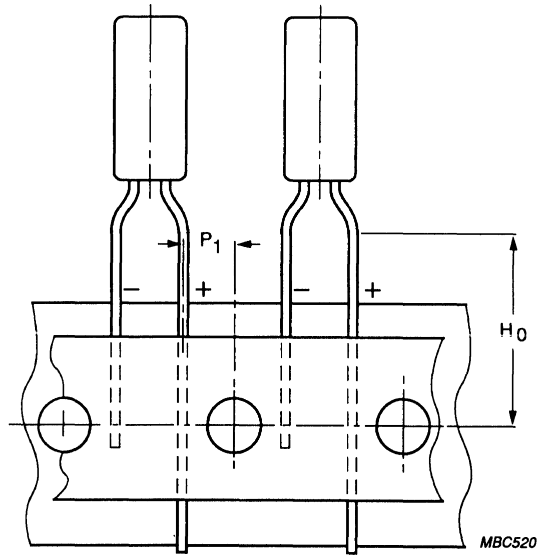
→ direction of tape transport for Form TR+ and TN+ (positive leading).

← direction of tape transport for Form TR- (negative leading).

Form TN+: 5 x 11: F = 2.5 mm.

Form TR+, TR– and **TFA:** 8.2 x 11: F = 5 mm.

Fig.1 Capacitors on tape, straight leads, case sizes 5 x 11 and 8.2 x 11.



→ direction of tape transport for Form TR+ (positive leading).
← direction of tape transport for Form TR- (negative leading).
Form TR+, TR− and **TFA:** 5 x 11: F = 5 mm.

Fig.2 Capacitors on tape, formed leads, case size 5 x 11.

PARAMETER	**Form TN+: F = 2.5 mm**	**Form TR+, TR− and TFA: F = 5 mm**		**TOLERANCE**
Case size ($\varnothing D_{nom}$ x L_{nom})	**5 x 11 (straight leads)**	**5 x 11 (formed leads)**	**8.2 x 11 (straight leads)**	
∅ D	5.5	5.5	8.7	max.
A	12	12	12	max.
∅ d	0.5	0.5	0.6	±0.05
P	12.7	12.7	12.7	±1.0
P_1	5.1	3.85	3.85	±0.7
P_2	6.35	6.35	6.35	±0.7
F	2.5	5.0	5.0	+0.6/−0.1
Δh	0	0	0	±2.0
Δp	0	0	0	±1.3
H	18	18	18	+1.5/−0
H_0	−	16	−	±0.5
H_1	32	32	32	max.

QUANTITIES per PACKING UNIT

Table 1 Number of capacitors per packing unit

CASE SIZE (∅ D_{nom} x L_{nom})	CASE CODE	BULK per box			TAPED per reel			TAPED ammopack
		Form CA	Form CB	Form CC	Form TR+	Form TR-	Form TN+	Form TFA
5 x 11	11	1000	1000	1000	1000	1000	1000	2000
8.2 x 11	13	1000	1000	1000	500	500	500	1000

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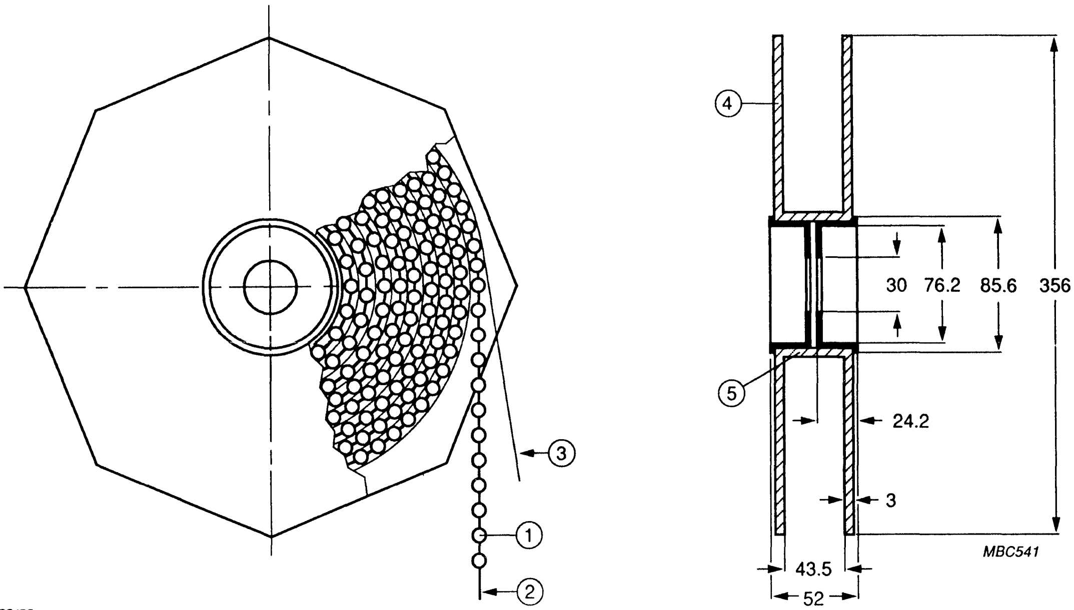
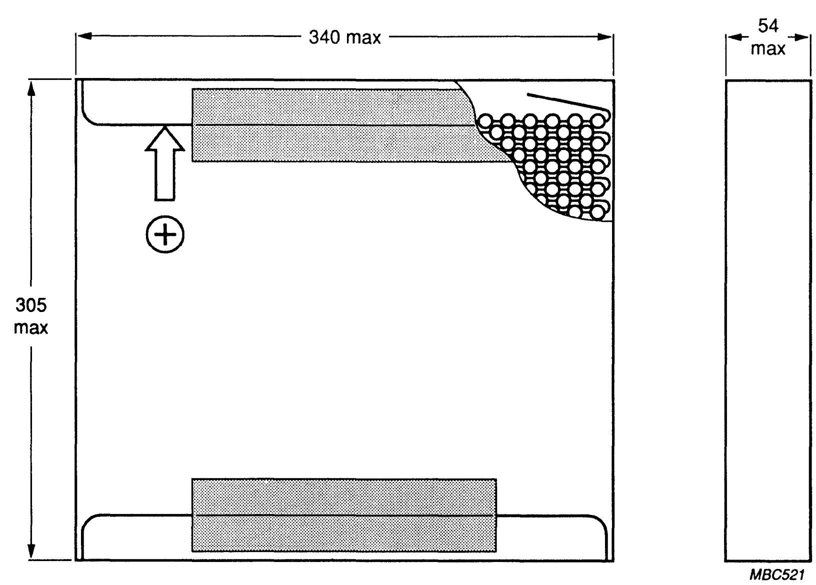


1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder.

Dimensions in mm.

Fig.3 Reel, Form TR+, TR− and TN+.



Dimensions in mm.
PREFERRED PACKING.

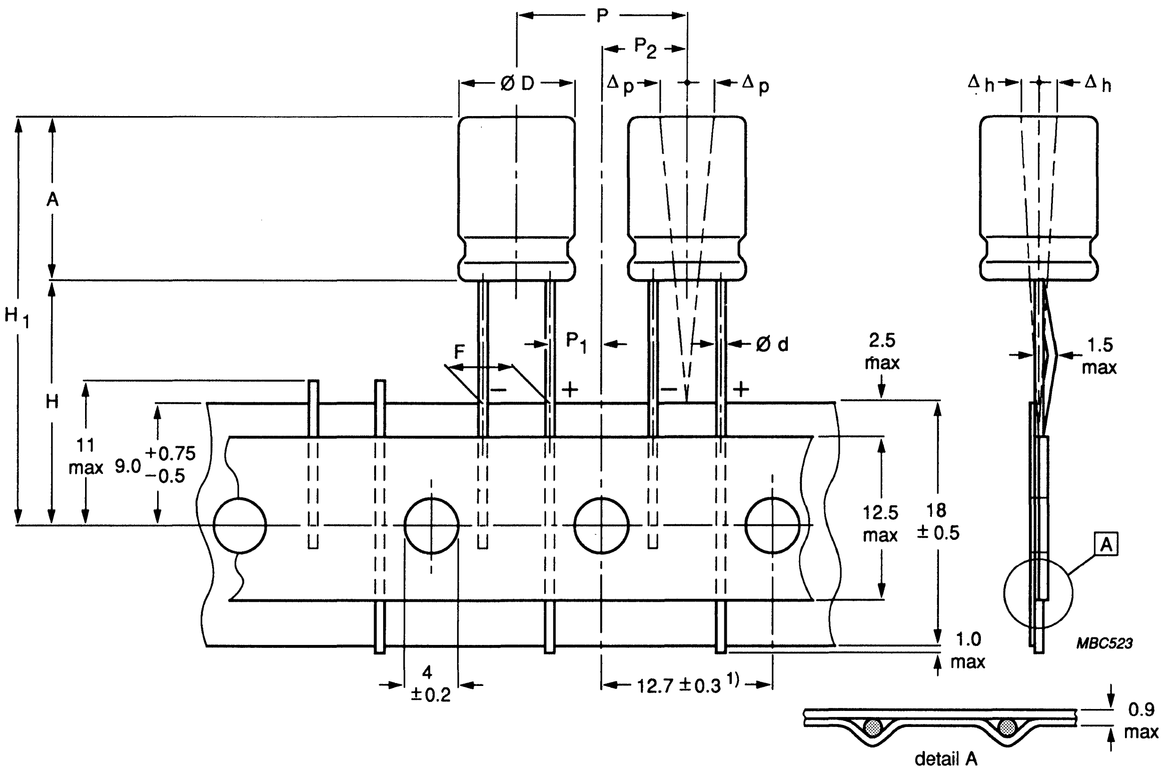
Fig.4 Ammopack, Form TFA.

The information contained in this part is valid for the following series:

- **2222 037 . . . . .**
- **2222 044 . . . . .**

with a case diameter (∅D) of 5 to 8 mm.

For catalogue numbers, refer to the relevant detail specification.



1) Tolerance over any 20 pitches: ±1.0 mm.

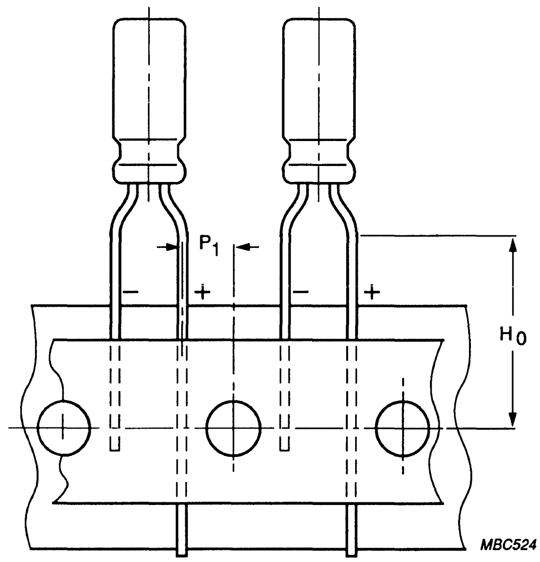
→ direction of tape transport for Form TN+ (positive leading).

Form TN+: 5 x 11: F = 2.5 mm (leads slightly bent)

6.3 x 11: F = 2.5 mm

8 x 12: F = 3.5 mm.

Fig.8 Capacitors on tape, straight leads, ∅ D = 5 to 8 mm.



→ direction of tape transport for Form TR+ (positive leading).
← direction of tape transport for Form TR- (negative leading).
Form TR+, TR– and **TFA:** F = 5 mm

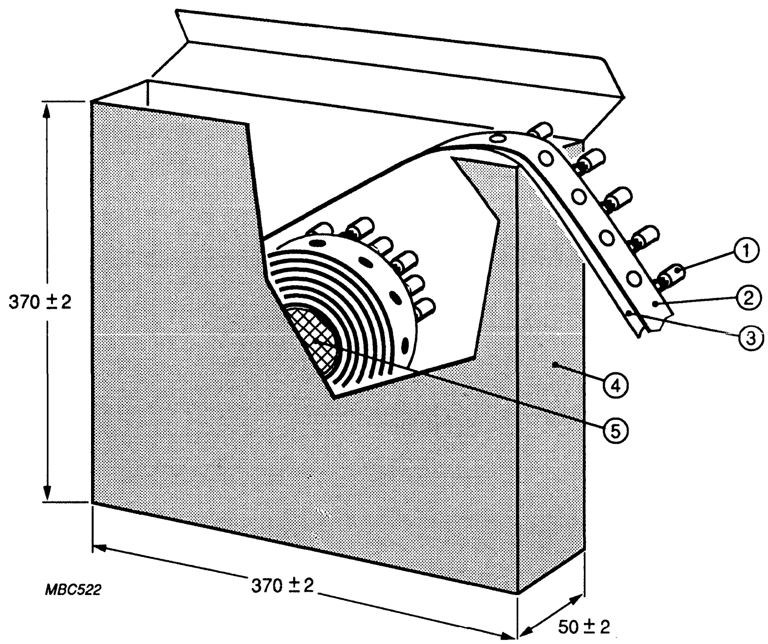
Fig.9 Capacitors on tape, formed leads, ∅ D = 5 to 8 mm.

PARAMETER	Case size (∅ D_{nom} x L_{nom})						TOLERANCE
	Form TN+			Form TR+, TR– and TFA			
	5 x 11	6.3 x 11	8 x 12	5 x 11	6.3 x 11	8 x 12	
∅ D	5.5	6.8	8.5	5.5	6.8	8.5	max.
A	12.5	12.5	13	12.5	12.5	13	max.
∅ d	0.5	0.6	0.6	0.5	0.6	0.6	±0.05
P	12.7	12.7	12.7	12.7	12.7	12.7	±1.0
P_1	5.1	5.1	4.6	3.85	3.85	3.85	±0.7
P_2	6.35	6.35	6.35	6.35	6.35	6.35	±1.0
F	2.5	2.5	3.5	5.0	5.0	5.0	+0.8/–0.2
Δh	0	0	0	0	0	0	±2.0
Δp	0	0	0	0	0	0	±1.3
H	18.5	18.5	20	18.5	18.5	20	±0.75
H_0	–	–	–	16	16	16	±0.5
H_1	32.2	32.2	32.2	32.2	32.2	32.2	max.

QUANTITIES per PACKING UNIT

Table 3 Number of capacitors per packing unit

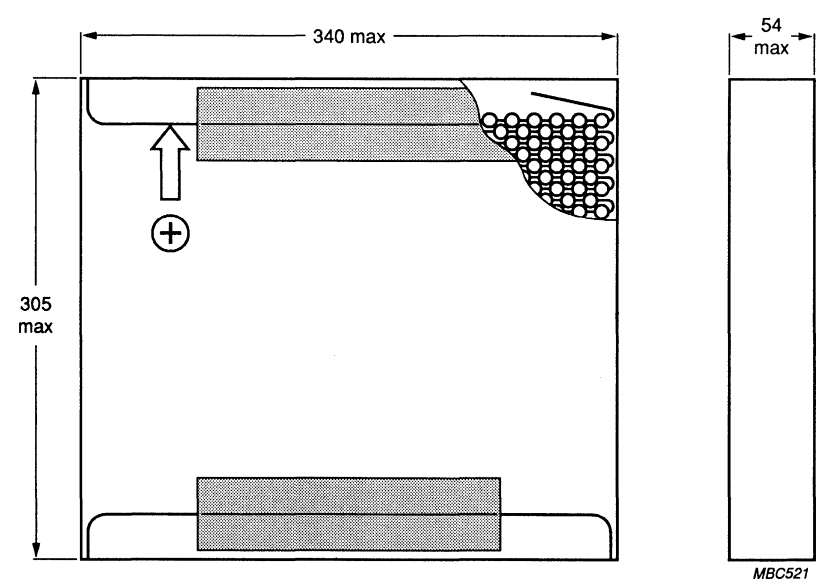
CASE SIZE ($\varnothing$ D_{nom} x L_{nom})	CASE CODE	BULK per box			TAPED per reel			TAPED ammopack
		Form CA	Form CB	Form CC	Form TR+	Form TR–	Form TN+	Form TFA
5 x 11	11	3000	3000	3000	1500	1500	1500	2000
6.3 x 11	12	2000	2000	2000	1000	1000	1000	2000
8 x 11	13	1000	2000	2000	800	800	800	1000



1 = capacitor
2 = tape
3 = paper
4 = reel box
5 = cylinder.

Dimensions in mm.

Fig.10 Reel packing box, Form TR+, TR– and TN+.



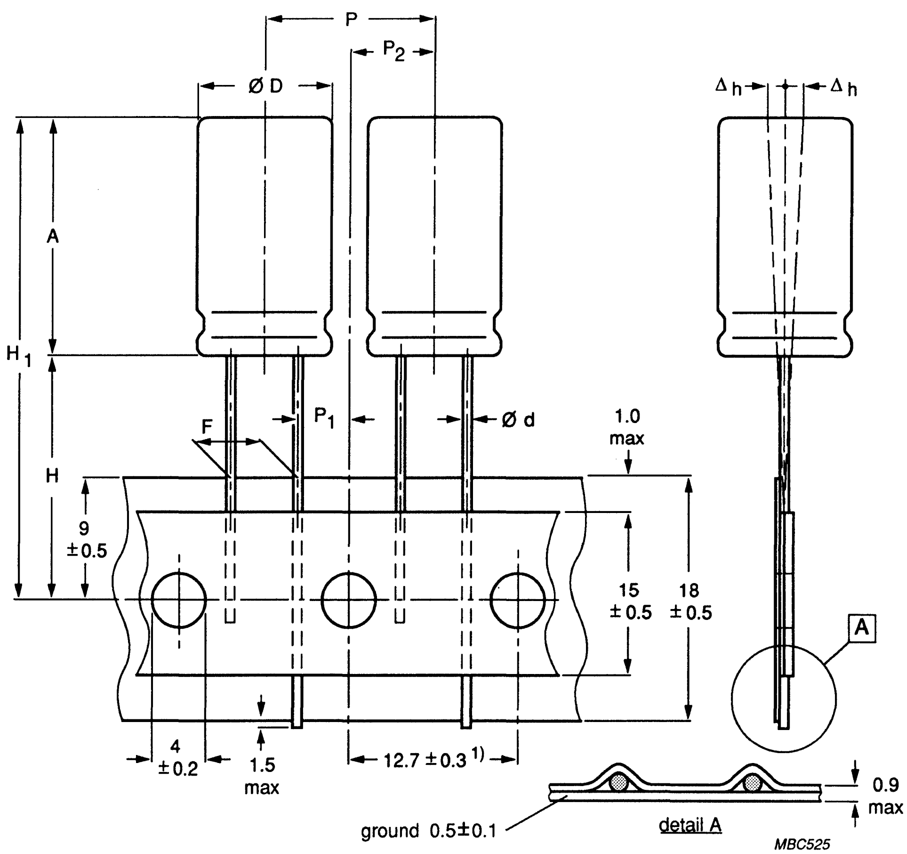
Dimensions in mm.
PREFERRED PACKING.

Fig.11 Ammopack, Form TFA.

The information contained within this part is valid for the following series:

- **2222 035 . . . . .**
- **2222 037 . . . . .**
- **2222 044 . . . . .**
- **2222 045 . . . . .**
- **2222 046 . . . . .**
- **2222 047 . . . . .**
- **2222 048 . . . . .**
- **2222 164 . . . . .**
- **2222 165 . . . . .**

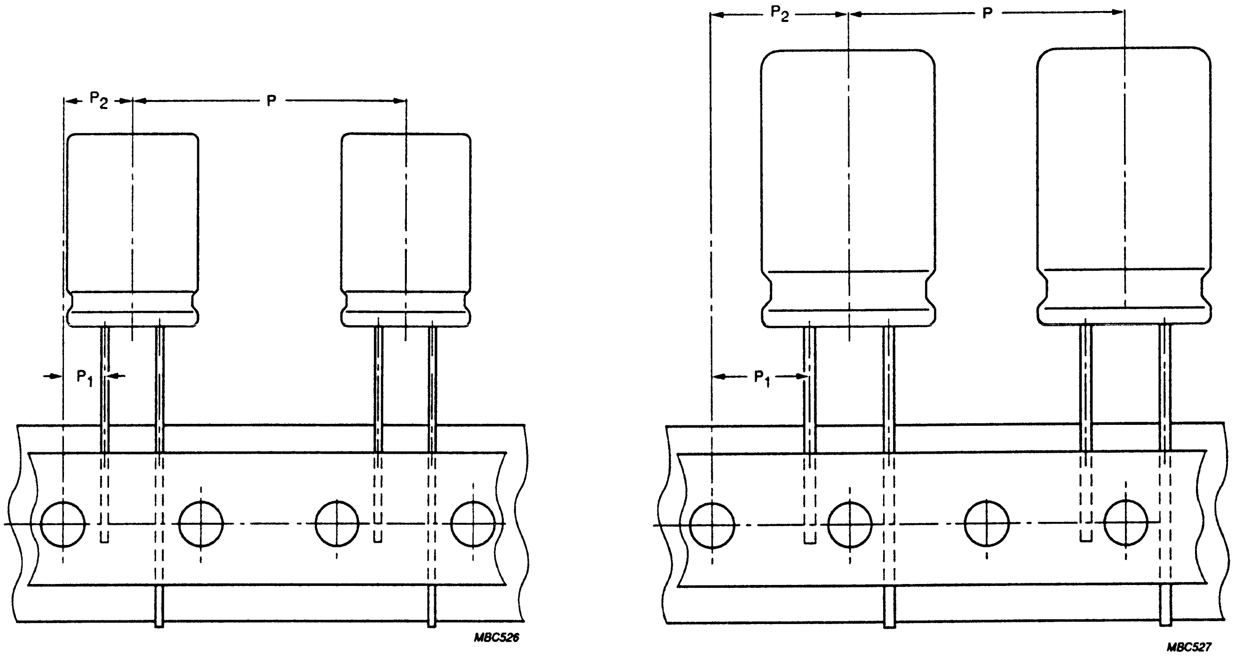
with a case diameter (∅D) of 10 to 16 mm.
For catalogue numbers, refer to the relevant detail specification.



1) Tolerance over any 20 pitches: ±1.0 mm.

→ direction of tape transport for Form TR+ (positive leading).

Fig.12 Capacitors on tape, ∅ D = 10 mm.



→ direction of tape transport for Form TR+ (positive leading).

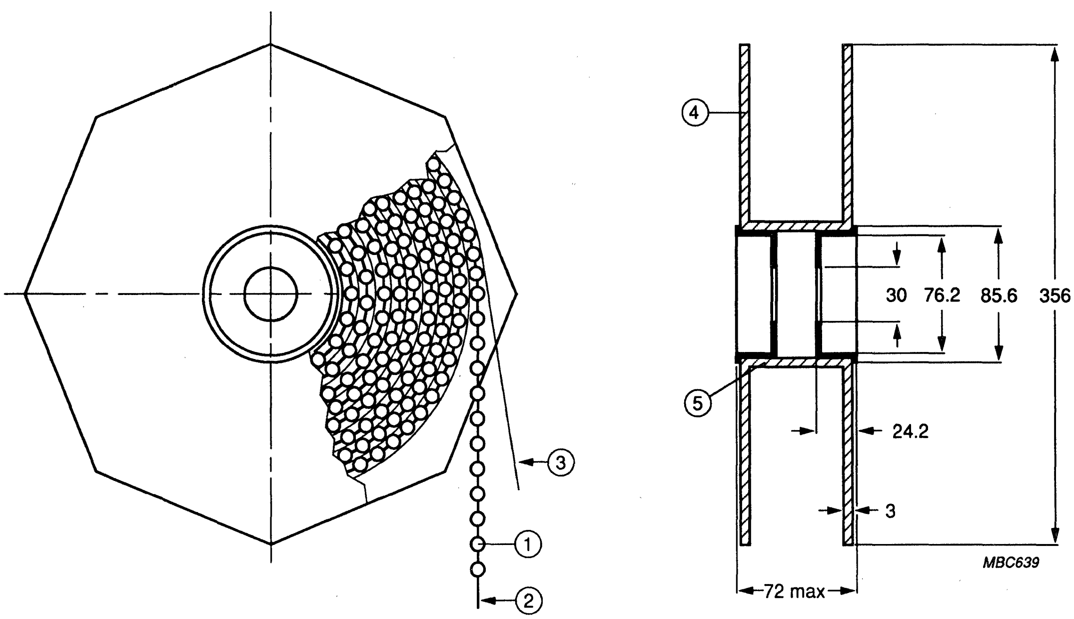
Fig.13 Capacitors on tape, ∅ D = 12.5 and 16 mm.

PARAMETER	Case size (∅ D_{nom} x L_{nom})							TOLERANCE
	10 x 12	10 x 16	10 x 20	12.5 x 20	12.5 x 25	16 x 25	16 x 31	
∅ D	10.5	10.5	10.5	13.0	13.0	16.5	16.5	max.
A	13.5	17.5	21.5	21.5	26.5	27	33.5	max.
∅ d	0.6	0.6	0.6	0.6	0.6	0.8	0.8	±0.05
P	12.7	12.7	12.7	25.4	25.4	25.4	25.4	±1.0
P_1	3.85	3.85	3.85	3.85	3.85	8.95	8.95	±0.7
P_2	6.35	6.35	6.35	6.35	6.35	12.7	12.7	±1.3
F	5.0	5.0	5.0	5.0	5.0	7.5	7.5	±0.8
Δh	0	0	0	0	0	0	0	±3.0
H	16.5	16.5	16.5	16.5	16.5	16.5	16.5	±0.5
H_1	30.5	34.5	38.5	38.5	43.5	44.0	50.5	max.

QUANTITIES per PACKING UNIT

Table 4 Number of capacitors per packing unit

CASE SIZE (∅ D_{nom} x L_{nom})	CASE CODE	BULK per box		TAPED per reel
		Form CA	Form CB	Form TR+
10 x 12	14	1000	1000	500
10 x 16	15	500	500	500
10 x 20	16	500	500	500
12.5 x 20	17	200	200	200
12.5 x 25	18	200	200	200
16 x 25	19	200	200	150
16 x 31	20	200	200	150
16 x 35	21	150	150	–
18 x 35	22	100	100	–
18 x 40	23	100	100	–



1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder.

Dimensions in mm.

Fig.14 Reel, Form TR+.

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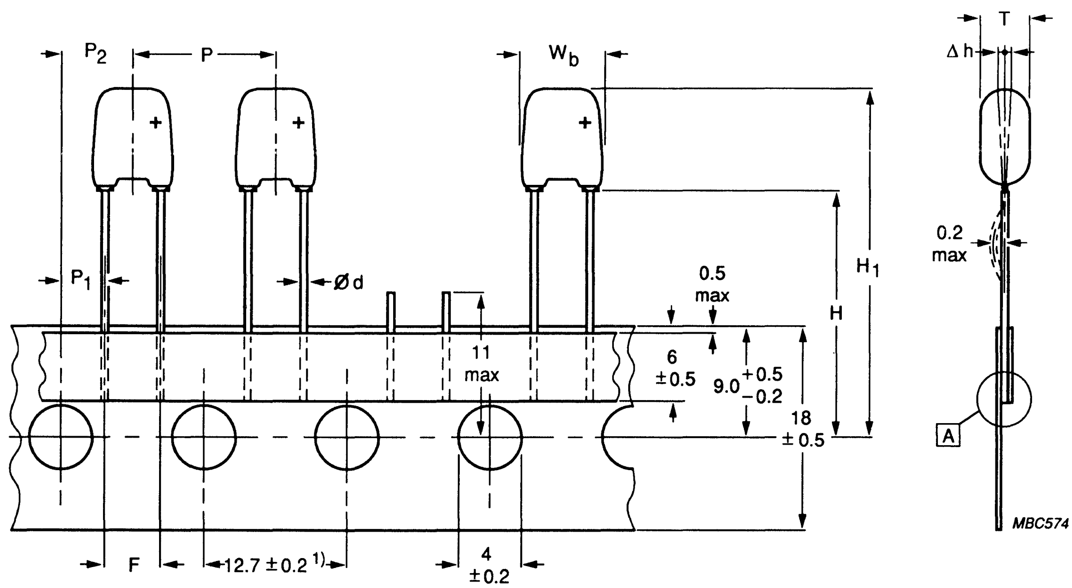
The information contained within this part is valid for the following series:

- **2222 128 . . . . .**

For catalogue numbers, refer to the relevant detail specification.



1) Tolerance over any 20 pitches: ±1.0 mm.

→ direction of tape transport for Form TR+ (positive leading).

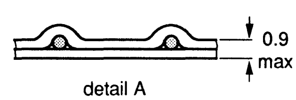


Fig.15 Capacitors on tape, max. capacitor height 9.5 or 12.5 mm.

Table 5 Tape dimensions in mm

PARAMETER	2222 128 . . . . . max. height 9.5 mm						TOLERANCE
CASE CODE	10	20	30	40	50	60	
T	3.0	3.5	4.0	5.0	5.0	6.0	max.
W_b	7.0	7.0	7.0	7.0	8.0	8.0	max.
Ø d	0.6	0.6	0.6	0.6	0.6	0.6	+0.02/−0
P	12.7	12.7	12.7	12.7	12.7	12.7	±1.0
P_1	3.85	3.85	3.85	3.85	3.85	3.85	±0.7
P_2	6.35	6.35	6.35	6.35	6.35	6.35	±1.0
F	5.2	5.2	5.2	5.2	5.2	5.2	±0.2
Δh	0	0	0	0	0	0	±1.0
H	18.5	18.5	18.5	18.5	18.5	18.5	±0.75
H_1	28	28	28	28	28	28	max.

1 = capacitor
2 = tape
3 = paper
4 = flange
5 = cylinder.

Dimensions in mm.

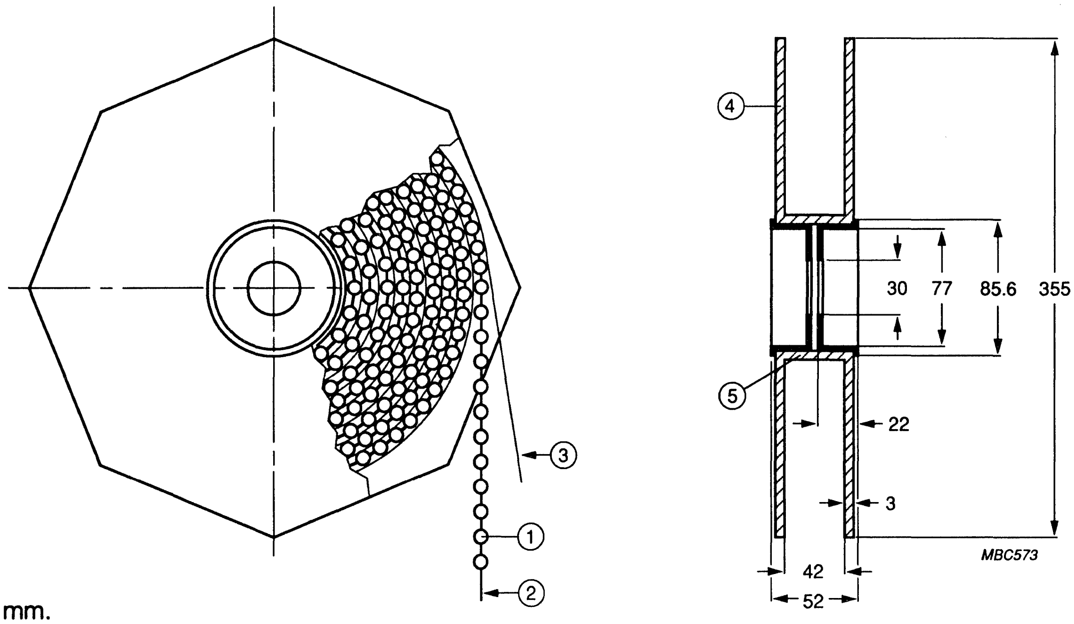
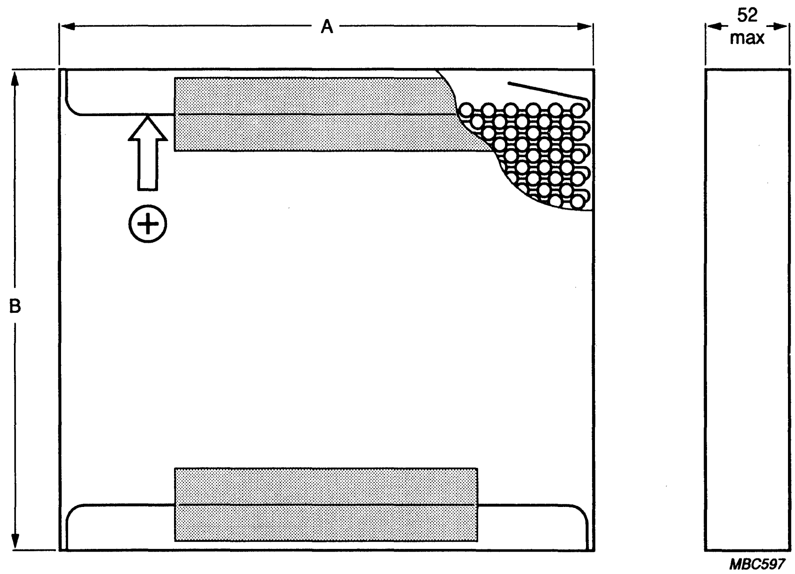


Fig.16 Reel, Form TR+.



Dimensions in mm.

PREFERRED PACKING.

Fig.17 Ammopack, Form TFA.

Table 6 Ammopack dimensions in mm

PARAMETER	2222 128	A_{max}	B_{max}
Case code	10, 20 and 30	340	266
Case code	40, 50 and 60	340	176

QUANTITIES per PACKING UNIT

Table 7 Number of capacitors per packing unit

CASE SIZE H_{max} x W_{max} x T_{max}	CASE CODE	BULK per box		TAPED per reel	TAPED per box
		Form CA	Form CB	Form TR+	Form TFA
12.5 x 8.0 x 3.5	1	1000	1000	2000	2000
12.5 x 8.0 x 4.5	2	1000	1000	2000	2000
12.5 x 8.0 x 5.0	3	1000	1000	1000	1000
12.5 x 8.0 x 6.0	4	800	1000	1000	1000
9.5 x 7.0 x 3.0	10	1000	1000	2000	2000
9.5 x 7.0 x 3.5	20	1000	1000	2000	2000
9.5 x 7.0 x 4.0	30	1000	1000	2000	2000
9.5 x 7.0 x 5.0	40	1000	1000	1000	1000
9.5 x 8.0 x 5.0	50	1000	1000	1000	1000
9.5 x 8.0 x 6.0	60	1000	1000	1000	1000

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